

SOCIAL DOMINANCE IN  
ANIMALS

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## ABSTRACT

Although the concept of social dominance lacks adequate definition it has been commonly understood as the most important determinant of social behaviour within groups.

This thesis first demonstrates the inadequacy of using arbitrary competitive tests frequently employed as measures of dominance, and then it examines and rejects the alternative grooming index. In an attempt to defend the concept competitive tests are re-examined and changes in both the conditions of competition and the dependent variables are explored. Finally, the experimental investigation into dominance measurement is abandoned in favour of a theoretical approach to the problems of measurement, function and definition. These three areas are shown to be inter-dependent, with the problem of definition being fundamental. An analysis of possible types of definition shows that no definition of "dominance" will suffice unless the term acquires an entirely new and restricted meaning.

NOTE: Figures 01 - 04 described in Experiment 1 and the data from which they were obtained were destroyed in a fire at the Addington Showground on September 13, 1975. Their descriptions and results of statistical tests, however, were presented in Chapter 2.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 THE ORIGINS AND DEVELOPMENT OF DOMINANCE THEORY

When Schjelderup-Ebbe (e.g. 1922, 1931) described "despotism" in the domestic chicken he laid the foundation for all subsequent studies of social dominance, widely accepted as one of the most important bases of social relationships within groups. Many of the assumptions of this early work, such as the principle of universal despotism, were rejected by behaviourists. According to this principle dominance was seen to characterize all interactions, even those of inanimate objects. Schjelderup-Ebbe (1922, 1931; quoted in Allee, 1938) writes, "Despotism is the basic idea of the world, indissolubly bound up with all life and existence. On it rests the meaning of the struggle for existence."

"There is nothing that does not have a despot... The storm is despot over the water; the lightning over the rock; water over the stone which is dissolved."

In Europe where Behaviourism has had less impact, Gartlan (1964) claims that the concept has undergone little change, but among British and American workers, the parameters chosen for more rigorous experimental study show that different assumptions are made. Unfortunately, failure to recognise these assumptions, to make them explicit, and to examine their validity has lead to confusion in the design

and interpretation of experimental work in this area, and in dominance theory. An indication of the lack of clarity concerning the concept is the absence of a generally accepted definition. This has prompted Gartlan (1964) to write, "Frequent use of the term is matched by the infrequency with which it is defined... One of the most striking aspects of the whole concept is that nowhere does one find an adequate definition of it, and inadequate attempts are few." He concludes, "Dominance is a concept which is so wide as to be meaningless." Attempts at definition have been made at two levels - operational and non-operational. / An example of an operational approach is Van Kreveld's (1970) definition: "In general terms, dominance is a priority of access to an approach situation or of leaving an avoidance situation that one animal has over another." In contrast, dominance appears implicitly as an intervening variable in Wood-Gush's (1971) statement, "High ranking birds which deliver the most threats and win the most fights also have priority for food, nests, roosting places and greater freedom on the pen."

The latter approach, which is closer to the traditional concept, clearly has the greater explanatory utility. Hence, there has been a marked tendency to favour this approach even in the face of apparently conflicting evidence. For example, Chance (1956) writes, "Dominance is usually defined as priority of access to a need satisfying object, but since in this instance no priority of feeding was shown, it was in the relations of the animals to each other that the order of rank was made manifest." Chance's definition of dominance sounds much like that of Van Kreveld. Unlike Wood-Gush,



neither of these writers make explicit the assumption of unidimensionality. Yet Chance is clearly going beyond his definition and as a consequence ends in circularity: Dominance both is the priority and gives rise to it.

There are two possible reactions to such unscientific thinking. The operational approach (e.g. Van Kreveld, cited above) may be adhered to more strictly, thus rendering the concept descriptive rather than explanatory, and precluding any inference of unidimensionality. Alternatively dominance may be rejected as a concept (e.g. Gartlan, 1964). The equation of dominance with priority of access renders the concept of little value unless there is some degree of concordance between the various indices of priority. In practice this approach has seldom been strictly adhered to and other implicit assumptions are frequently evident. Van Kreveld (1970) himself indicates that aggression should be regarded as the basis for dominance relations where the various priority measures do not correspond. This not only violates his own definition but also suggests that Schjelerup-Ebbe's studies still exert considerable influence. In practice there are problems peculiar to the aggression measure. Reduced or absent aggression is often attributed to settled dominance relationships, with greater differences in rank being associated with fewer agonistic encounters (e.g. Bernstein, 1970). Thus, using this index, we are faced with a possible dilemma, being able only to measure dominance relationships which are unsettled or non-existent.

This has given rise to a more far-reaching assumption which is common to a great number of writers. The difficulty

in obtaining aggressive orders in stable groups has prompted researchers to use alternative indices of group status. Where authors have required relatively simple tests of dominance, few attempts have been made to validate the chosen measures but rather the generality of priority measures has been presupposed. Wood-Gush's (1971) statement quoted above is the explicit statement of a view which is uncritically accepted as true for all species in all contexts. The literature is rich with examples. Among them are studies on the effects of drugs (e.g. Uyeno, 1966, 1967; Heimstra and Sallee, 1965); gentling (e.g. Mezei and Rosen, 1960); housing conditions (e.g. Ward and Gerall, 1968; Uyeno and White, 1967); and group size (e.g. Becker and Flaherty, 1968), etc.

As the number of incompatible findings increased a few reviewers took a more critical approach. Gartlan (1964) presented a list of eight characteristics and their opposites. All sixteen characteristics had appeared in the literature as principal features of dominance. Inconsistencies were presented not merely between authors but within the context of a single study. Focussing on the behaviour of East African monkeys, Gartlan regarded the formation of hierarchies as a pathological symptom which resulted from the stress caused by such factors as environmental restriction. Referring to activity specific hierarchies which were observed in the field (Kummer and Kurt, 1963), he claims that incidental learning is a parsimonious explanation both for this and for other otherwise inexplicable phenomena such as the formation of triangular relationships. Gartlan concludes his strong attack with a call for the rejection of the whole concept:

"It is a concept which has probably done much more harm

than good and which has long outlived any usefulness it may once have had; there is no justification for retaining it in an objective behavioural science."

In its place he suggests a more objective description of the behaviours to which dominance is reducible.

Although Gartlan presented a very forceful case, it is doubtful whether his paper had any impact in areas other than that of primatology. Elsewhere, and indeed among many primatologists, dominance remained a perfectly respectable concept. Dominance studies continued to proliferate, and simple competitive tests were employed as measures of social dominance. Dominance was roughly equated with social behaviour, and the hierarchy with social organisation.

In 1974, four reviews or papers containing comprehensive reviews appeared in the literature (Richards, 1974; Rowell, 1974; Spigel and Fraser, 1974; and Syme, 1974). Richards and Rowell both focus on primate behaviour, with Richards favouring the retention of dominance as an intervening variable, while Rowell argues that subordination is a more useful concept. Spigel and Fraser are particularly concerned with rodent studies and suggest that social grooming is a more stable and consistent index of dominance than is performance in competitive tests. Syme, like Gartlan, argues that where results may be interpreted as indicating individual differences in skill at the competitive task this interpretation must be favoured over dominance hypotheses on the grounds of parsimony. His review of the literature shows the findings presented in a number of studies are inconsistent with the traditional unidimensional view of dominance. He thus stresses the importance of validating competitive tests

as measures of dominance.

While all four reviews are briefly dealt with below, Syme's review is of particular relevance to this thesis insofar as the essence of his paper was available as a doctoral dissertation prior to the research presented in the succeeding chapters. The other papers have appeared subsequently.

## 1.2 CONTEMPORARY THOUGHT

Syme (1974) compiled a large number of objections to the use of competitive measures as indices of dominance. For some considerable time there had been an awareness among some authors that an "any test will do" approach was unjustified. For example, Bruce (1941) wrote of his paired-comparisons food competitions in rats, "It is quite obvious that using other temporal intervals would give different experimental results. There is real question what temporal interval would provide the most valid data... Further experimentation is needed before this question is settled."

But the question remained unsettled, and the literature bears record to a large number of writers who were either ignorant of this consideration or turned a blind eye to it. This remained the case until Syme, Pollard, Syme and Reid (1974) systematically investigated the validity of limited access measures as indices of social dominance in rats. The effects of this publication are yet to be seen.

In the meantime there were other misgivings about competitive orders. Becker and Ezinga (1969) raised doubts about the use of rotated pairs, the most frequent method of

establishing hierarchies of social status. The use of permanent pairs was recommended as a means of eliminating serial effects based on stimulus generalisation in interaction with the experimental manipulation or sampling error.

Becker (1965) suggested control for emotionality when dominance in small groups is being observed as an effect of some experimental manipulation. Baenninger (1970) found reliable orders for food, water and spontaneous dominance in the laboratory rat, but only food and water orders had a significant positive correlation. She concluded that no order was the basis of any other, and that dominance orders are not unidimensional in this species. Lindsey, Manosevitz and Winston (1966) showed that not merely the type of reward, but the nature of the competition for that reward was an important determinant of success. They showed for two strains of mice that measures of arena (limited access) competition for food and aggression were concordant, while both measures were negatively related to performance in the dominance tube (food reinforcement).

Syme, Pollard, Syme and Reid (1974) showed that within a competition of a given type (limited access) with a given reward, small changes in the response requirement yielded a different competitive order. Thus, the nature of the reward, the type of competition, the response requirement within competition of a given type, and the duration of competition had all been shown to affect the orders obtained. Comparison between studies made it increasingly obvious that competitive tests should not all be assumed to indicate social status. For example, Uyeno and White (1967) reported isolated rats were dominant over group-reared subjects, while Rosen (1966)

reported the reverse. Ruskin and Corman (1971) reported a high correlation between aggression and food competition, while Baenninger (1970) reported the reverse.

While these studies together constituted a strong challenge to traditional dominance theory, independently their effects were not great. Something was clearly amiss, but it was 1974 before evidence was amassed and presented against the use of arbitrary competitive orders as measures of dominance.

Syme (1974), after accumulating evidence from a large number of studies, stresses the importance of establishing the internal validity (i.e. Is the observed priority mediated socially?) and external validity (generality) of competitive measures.

In the absence of unidimensionality, discrepant findings may be attributable to differing methodologies. Syme calls for procedural standardization of competitive tests and gives a list of methodological inconsistencies which must be resolved before such standardization is achieved. Some of these issues are dealt with in the course of this thesis.

While Syme advocates and suggests a framework for standardization of procedures, Spigel and Fraser (1974) offer an alternative solution. These authors are primarily concerned with rat behaviour but they review dominance studies in a variety of species in order to show the extent to which procedural variation may account for the vast disagreement concerning treatment effects and the relevant variables. On the basis of an earlier study (Spigel, Trivett and Fraser, 1972) and other unpublished research they advocate the assessment of dominance relationships from grooming

behaviour rather than competitive tests. However, under such circumstances the problem of definition is even more acute. Van Kreveld's definition is inadequate and an alternative may prove elusive unless dominance is redefined in terms of grooming. If possible this step should be avoided since the meaning of dominance would either be unrelated to the historical usage and superfluous, or it would become species-dependent. For example, dominant rats groom submissive partners (Spigel, Trivett and Fraser, 1972), whereas the reverse is true of primates (e.g. Kaufmann, 1967).

While the reviews of Syme, and Spigel and Fraser are more directly relevant to the present thesis, mention must be made of the other recent reviews previously referred to. Hopefully a more balanced appraisal of contemporary thought will thus be given.

Richards (1974) is another author who is aware of contradictions in the literature both in experimental findings and in interpretation.

Ten measures of dominance are compared. These are based on observations of six groups of rhesus macaques. The measures include four competitive (priority) measures, four measures of gestures, agnostic interactions, and displays. All measures ranking all group members were found to correlate positively. The four measures of food priority were consistently among these. On the basis of these findings Richards infers that the concept of a social dominance hierarchy has some value where dominance is viewed as an intervening variable. Richards suggests possible reasons for the lack of agreement between measures in other studies and concludes that there is a need for adequate definition of

the terms used in dominance theory, and for definite procedures yielding strictly defined measures which cut across many social situations. Correlation between these measures warrants retention of dominance as an intervening variable.

While Richards presents evidence for the retention of the dominance concept, his other suggestions are consistent with those of Syme (1974) without laying the same framework for standardization.

Rowell (1974) refers to the overwhelming importance that has been attributed to dominance relations, and the tacit assumption that hierarchy equals social organization. She propounds an alternative theory of subordination based on learning. She argues that it is the subordinate animals which turn interactions into approach-retreat "dominance" interactions, claiming that the decisive role of the subordinate animal is particularly clear in simple avoiding behaviour or supplanting. In these cases the dominant animal does not make any overt acknowledgment of the other's presence. She cites Mason (1961) who found cringing on the part of the subordinate was the best indicator that a dominance relationship had been established, Rowell (1966) who found it was the behaviour of the subordinate baboons in approach-retreat interactions which correlated best with rank, and Scruton (1970) and Chance (1967) who discussed the "looking at" behaviour (or attention structure) of low ranking talapoins and macaques respectively toward higher ranking animals, independent of the latter's behaviour.

Rowell suggests that subordinates observe and maintain dominance hierarchies. She describes subordinate behaviour in monkeys which may elicit dominating behaviour



and suggests this type of behaviour is the most common antecedent to attack. These behaviours include cringing, fleeing and fear grinning which Rowell claims are "extremely potent stimuli eliciting attack behaviour in primates". The harassing and supplanting described in primate literature, Rowell says, may merely be one animal yearning for a grooming bout with a nervous cagemate.

She argues that the concept of subordination makes better biological sense than dominance. Hierarchies are most often observed in captive rather than free-living groups. The subordinates' behaviour is most aberrant when compared with their free-living counterparts, both in terms of the frequency and duration of certain postures, and in the incidence of stress-related diseases. Rowell claims that explanation in terms of dominance is less economical than explanation in terms of subordination. The former requires two stages: conditions of captivity eliciting dominance behaviour which in turn is responded to with subordination, stress and stress-related diseases. Dominance has no known physiological correlate.

At some points Rowell's assessment, though less extreme, resembles that of Gartlan (1964) who concluded that the formation of hierarchies is a purely pathological symptom. The importance of incidental learning is also stressed by both authors.

In these four recent reviews there is a unified call for a more enlightened methodological approach. At the same time there is diversity in the authors' views on dominance.

Syme (1974) denies the unidimensionality of dominance and discusses the methodological implications of rejecting this assumption. Richards (1974), who like Syme calls for

procedural standardization and adequate definition of terms, views dominance in a global, if not unidimensional, sense. He favours the retention of dominance as a useful intervening variable. Spigel and Fraser (1974) discuss the methodological inconsistencies in the literature as the source of discrepant findings but do not discuss the implications to general dominance theory. Instead they advocate the use of a grooming index of social dominance in the rat. Rowell (1974) takes a more theoretical approach. Her concept of subordination has some appeal. On the other hand her views may be a result of specialization in primate behaviour. Rowell argues that if dominance is universal this specialization is unimportant. This is peculiar insofar as she not only presents a case against dominance, but also for subordination. Her approach is appropriate for destroying the traditional concept of dominance (viewed universally) but weakens her case for the alternative she is suggesting. The usefulness of the subordination concept is restricted not merely by consideration of species, but also by consideration of the components of subordination behaviour. Problems of definition and standardization of procedures are merely transposed from one framework to another. However, Rowell's emphasis on learning and situation-specificity in social relationships provides a certain amount of protection against the unwarranted assumptions of traditional dominance theory.

These reviews provide an incomplete but representative insight into the vanguard of thought on social dominance (see also Hinde, 1974). Meanwhile, studies which make all of the assumptions of traditional dominance theory (e.g. dominance is unidimensional, any test will do) continue to appear in

the literature (e.g. Taylor and Moore, 1975).

### 1.3 FUNCTIONS OF DOMINANCE

So far the problems of definition and of measurement have been discussed. However one further problem remains - that of function. Neither of the two most commonly assumed functions of "dominance" tally with the evidence available in the literature:

- i. It is not clear that the formation of dominance relations reduces aggression. Hierarchies are most often found where aggression levels are high. In stable groups aggressive encounters are rare and dominance relations difficult to measure (e.g. Hinde, 1974).
- ii. The inference of reproductive success from priority of access to females is also invalid since receptive females do not always contain ripe ova. Neither can this priority be generally assumed. De Vore (1965), for example, describes high ranking male baboons as relatively inactive sexually.

Rowell's (1974) argument for the adaptive nature of a range of adrenal responsiveness within a group sounds plausible. However, the step from adrenal responsiveness to subordination is as yet unjustified, particularly since there is no generally accepted definition of subordination.

The absence of any clear definition of dominance, the absence of any clear function, and the absence of any generally accepted means of measurement are factors strongly challenging the retention of the concept of social dominance. The confusion evident in the literature will continue until

either solutions are found to these problems or the concept is abandoned.

CHAPTER TWOGROUPED VERSUS ISOLATED SUBJECTS: AN EXAMPLE OF  
SITUATION SPECIFICITY IN COMPETITIVE MEASURES OF DOMINANCE

Studies on the effects of social isolation upon competitive success in the rat provide one example of inconsistency in the dominance literature. The findings of these studies are incompatible insofar as the various tests are assumed to measure the same attribute. In the studies discussed below the authors all assume that the competitive tests chosen are valid measures of social dominance.

Studies on social isolation are of interest to the extent that they show how much dominance behaviour is dependent upon social experience. Rosen (1961) found no significant difference in the competitive success of isolated and socially-reared rats in a limited access drinking situation. However, Rosen (1964) found socially-reared animals more successful than isolates in a limited access food competition. Both Uyeno and White (1967), using an underwater dominance tube, and Ward and Gerall (1968), using a conventional dominance tube, found isolated rats to be more successful than group-reared rats. Hoyenga and Lekan (1970) showed no significant difference between isolated and group-reared rats in a limited access food competition, although over early sessions the group-reared animals met with greater success.

The strains used for these studies were Wistar (Rosen 1961, Uyeno and White 1967), Sprague-Dawley (Ward and Gerall 1968, Hoyenga and Lekan 1970), and hooded rats of unspecified strain (Rosen 1964). Hence the different results cannot be

entirely explained in terms of strain differences. Differences in type of competition (limited access or dominance tube); rewards (food, water, air); time and duration of isolation; size of groups for socially-reared animals; length of familiarization period; dependent variables (e.g. time in control of food or water source versus weight consumed); competitive test times (e.g. compare Rosen (1961) and (1964) using a 5 minute test period, with Hoyenga and Lekan (1970) using a 2 minute test period), and, finally, the methods of data analysis, make comparisons between these studies difficult. In addition these authors seldom relate their work to each other. Only Ward and Gerall (1968) mention any of the other authors and they refer to Rosen (1961) but not to Rosen (1964). Rosen (1964) mentions Rosen (1961) only as the source of his definition of "dominance" - he never mentions his earlier findings which, on the surface, appear contradictory. Although the overall implications of these studies seem obscure it is interesting to note that the only study showing group-reared animals to be more successful than isolated animals was conducted in the limited-access setting (Rosen 1964). On the other hand, the two studies showing isolated animals to be more successful both used a dominance tube. The present study consists of experiments conducted in these settings and is aimed at further investigating this difference.

## 2.1 EXPERIMENT 1

Of the studies using the limited access situation, the most interesting is that of Hoyenga and Lekan (1970).

Rosen (1964) reports the only significant difference between grouped and isolated animals but his results are difficult to evaluate in view of his inappropriate method of data analysis (Syme and Doak 1974, see Appendix). This is also true of his earlier work.

Hoyenga and Lekan (1970) found isolated animals to be less active than their grouped counterparts in an open-field pre-test. With practice in the subsequent competitive test both groups were found to increase in competitive efficiency, as measured by weight gained in the experimental setting. The socially-reared rats met with greater success over the initial encounters but this difference had disappeared by the ninth day.

The distinctive features of the study were the use of weight gained as a measure of success, and of the single familiarization trial. While these authors interpret the increased competitive efficiency in terms of the diminished attention paid to the socially-reared subjects by the isolated subjects, it seems likely that increased familiarization with the test apparatus may have played an important part. The present study investigates the effect of extending the familiarization period, and of comparing time in control of the reward source with weight gained during competition.

#### 2.1.1 SUBJECTS

The subjects were 14 female hooded rats (Otago Strain NZBWS), randomly divided into two groups at weaning (21 days). Seven rats were housed together in a cage measuring 0.75 x 0.33 x 0.45m high, and 7 were housed individually in cages measuring 0.18 x 0.18 x 0.18m high. All subjects were

maintained on a reversed light/dark schedule and were permitted free access to ad lib food and water.

### 2.1.2 APPARATUS

The test chamber consisted of a metal box measuring 33 x 33 x 33cm high with a plexiglass door forming one side and permitting direct observation of the interior. The metal parts were painted white. In one wall, at floor level, there was a recess of such dimensions (diam. 3cm, depth 2cm) that only one rat could fit its head in at a time. In the floor of the recess there was a small hole allowing the animals to drink from a water trough outside the chamber. Illumination was provided by four 10W bulbs mounted in a unit in the roof.

### 2.1.3 PROCEDURE

At age approximately 100 days the tails of the subjects were dyed to permit individual recognition, and the subjects were placed on a 23½ hour water deprivation schedule. On the seventh day of deprivation experience each rat was placed alone in the test chamber for 10 minutes. Water was available at the drinking trough, and all subjects drank before the 10 minutes had expired. Following this each subject was returned to its home cage and all were given ad lib water for 30 minutes. The following day baseline measures were begun. Each animal was weighed prior to a 2 minute test period in the test apparatus. The time spent drinking in this period was recorded on a stopclock and, at the end of the test period, the subjects were re-weighed



and the weight increase calculated. At the end of testing 30 minutes of ad lib water was again given to all subjects.

The baseline measures were continued for 22 sessions after which the mean time spent drinking was over 80 seconds per animal for each group (grouped rats 91.6secs, isolated 85.1secs). On the basis of these figures 80 seconds was chosen as an appropriate competitive period (Syme, Pollard, Syme and Reid, 1974). Seven daily sessions of competition followed. With one encounter each per day this allowed each animal from the isolated condition to be paired once with each animal from the grouped condition.

#### 2.1.4 RESULTS \*

The mean time and mean weight-gains for each group are shown in Figure 0<sub>1</sub> under baseline conditions, and Figure 0<sub>2</sub> under competitive conditions. The problem of ipsativity in the analysis of this type of data is discussed by Syme and Doak (1974, See Appendix). Since care was taken in the present study to ensure a competitive period, the times spent drinking were compared for each pair in each encounter. The member of each pair spending the greater time drinking was scored with a win, the opponent with a loss. The results for the grouped animals only were then analysed in terms of number of wins as compared with number of wins expected, using a two-tailed Wilcoxon Matched-Pairs Signed-Ranks Test.

Assuming no difference between the two experimental conditions, the chance expectancy is 3.5 wins to each

\* For figures referred to in this and the following section (Discussion) see Note page 1.

competitor. The test showed the grouped animals to have performed significantly better than might be expected by chance ( $T = 0$ ,  $P = 0.02$ ).

The analysis in terms of weight presents a more difficult problem and one which has been inadequately handled in the literature. This is the problem of individual differences in drinking skill which are particularly critical where small groups are used. Control by the use of appropriate competitive periods (Syme et al, 1974) is effective where time measures are used, but not for weights. For this reason the total weight gained by each animal was computed and compared for the final seven days of baseline. On the basis of these weights, the expected number of wins was calculated for each animal by predicting a win where the total weight gained was greater than that gained by the opponent. The actual wins were obtained by comparing weights gained in competition. These were then compared with the expected number of wins for the grouped animals using the same test. There was no significant difference between the two ( $T = 6$ ,  $P > 0.05$ ).

#### 2.1.5 DISCUSSION

Before discussing these results it is important to point out two major departures from the studies cited previously, particularly that of Hoyenga and Lekan (1970). Firstly, male rats were used in all of the studies concerned with the effects of isolation upon competitive success. Because no males were available at the time of the present study, females were used. Archer (1969) found that female rats isolated for 24 weeks were significantly less active in

an open field than animals housed in groups of three, five or eight for the same period. On replicating this experiment with male rats no significant difference was found.

These animals had all previously been isolated (for six weeks) from weaning, and had been subjected to their respective housing conditions for somewhat longer than the subjects of the present study. In spite of this there remains the possibility that any effects observed in the present study would not have been evident had male subjects been used. Isolation has been shown to decrease activity in both males and females (Hoyenga and Lekan, 1970).

The second point of difference is the use of water rather than food reinforcement in this setting. Water was chosen because in order to drink the subject is forced to remain at the reward source. Food can be removed and consumed elsewhere. These factors must be considered when comparisons are drawn with the studies in the literature.

Figures  $O_1$  and  $O_2$  show the daily mean times each group spent drinking during baseline and competition respectively. Figures  $O_3$  and  $O_4$  show the weight increases over these two conditions. Hoyenga and Lekan (1970) compared absolute weight gains, but the results of the present study have been analysed in the manner above in an attempt to control for individual differences in drinking capacity. However, the graphs are useful in comparing the present findings with those of Hoyenga and Lekan.

The most striking feature of the baseline trend is the fall in both time spent drinking and weight gained for the grouped animals on day 12. This corresponded to an error in the feeding schedule. There is an overall upward trend in

times and weights over baseline levels for both grouped and isolated animals. This continues, with the exception already referred to, until about day 16 when an asymptote was reached.

The baseline graphs thus resemble the competition graphs of Hoyenga and Lekan (1970). They suggest the upward trend depends upon the decreasing novelty effect each grouped animal has on its isolated counterpart. The present study does not support this interpretation, but rather suggests that the effect is due to familiarity with the whole test environment, and perhaps the effects of handling as well. This interpretation is reinforced by consideration of Figures  $O_3$  and  $O_4$ . No trend is evident for either graph.

As in Hoyenga and Lekan's study, the grouped animals appear to drink more over the initial trials. This difference does not disappear until the latter part of baseline and reappears in competition. When times are considered the present study supports the findings which Rosen (1964) claims: that grouped rats are more successful than isolated rats in the limited access setting. Considering weights, on the other hand, the method of analysis employed here shows no significant difference between the two experimental groups. Thus the conclusions of Hoyenga and Lekan are supported. One question which must be dealt with is, does time or weight provide the more valid measure of limited access competitive success? This experiment suggests that they are not measuring the same thing, thus supporting the conclusions of Hoyenga and Rowe (1969), and Syme, Pollard, Syme and Reid (1974).

## 2.2 EXPERIMENT 2

### 2.2.1 INTRODUCTION

Hoyenga and Lekan (1970) found that grouped male rats were more active in the open field than isolated ones. Archer (1970) similarly found with female rats that activity as measured by locomotion increased as group numbers increased from one to three to eight. Since grouped rats scored more highly in terms of activity it is reasonable to expect isolated animals to be more often immobile. If this is so it will affect our predictions about the relative successes in the types of apparatus used in this study.

In the limited access setting, immobility can only be seen to negatively affect competitive success. In the dominance tube, however, the competition is of a completely different nature: it can be won by the winner advancing or by the loser retreating. Where the limited access test demands an active winning or a passive losing, the dominance tube test can be actively won or lost, and complete immobility may be an aid to competitive success insofar as the opponent may ultimately lose by reversing. Syme (1972) found that with a short habituation period a negative relationship between running times and competitive performance in this test was obtained. He suggests that the slower animals may be generally less active and have greater inertia in the apparatus. Hence, they take longer to move anywhere from the centre door, the result being a loss to the opponent in the manner described above. He notes, "the ultimate loser was frequently observed to make several rushes at the opposing animal, which itself remained stationary for some

time and then only slowly moved down the tube, even if the opposing rat retreated as far back as the opposing goal box... there are two definite behavioural components in the dominance tube: approach and retreat".

Thus, it is not unreasonable to expect isolated animals to be more successful than the more active group-reared animals as Ward and Gerall (1968) found.

Experiment 2 further examines the difference in approach and retreat between grouped and isolated rats. The experiment attempts to discover which animals would be first to lose a dominance tube encounter by retreating. One difference between this experiment and normal dominance tube encounters is the absence of any direct confrontation between pairs of animals. To this extent the test is a non-social one.

#### 2.2.2 SUBJECTS

As for Experiment 1.

#### 2.2.3 APPARATUS

The dominance tube was constructed of wood painted with white semigloss, with a plexiglass top to enable observation of subjects. The runway was 1.21m long, 6.3cm wide, and 6.3cm high. At each end of the runway was a start/goal box 22.9cm long, 8.9cm wide and 8.9cm high, where water was available at a drinking tube. These were separated from the runway by two guillotine doors. A third guillotine door was used to divide the runway halfway along.

#### 2.2.4 METHOD

Following Experiment 1 the subjects were given ad lib water for seven days, after which time they were again placed on a 23½ hour deprivation schedule. On Day 8 each animal was placed alone in the dominance tube with all doors open. Water was available at each end. The following day the rats were run individually for six trials from alternative goal boxes to the goal box at the opposite end where they were permitted to drink for 10 seconds. The central guillotine door remained open. This was continued for 8 days with the time taken to traverse the runway being recorded. On the final day of testing the central door was closed and the time was recorded from the opening of the start box door to the animal's arrival at the centre door. The time taken from the arrival at the centre door until the subject had retreated back into the goal box was also recorded. Once the subject had retreated in this manner the central door was opened and the rat was permitted to run down to the other end of the runway to drink. Each subject had six such trials from alternative ends.

#### 2.2.5 RESULTS

All trials taking longer than 5 minutes were recorded as 300 seconds. For the six test trials the results for each animal were compared with those for each other animal from the opposing group. Thus there were 49 different pairings of six trials each; a total of 294 pairings. Each animal was scored with 1 point if its time was longer than that of its "opponent"; 0 points if its time was shorter; and ½ a point if both times were equal. The results of the grouped animals'

encounters were then compared with the chance expectancy of 21 out of 42 for each animal. Two-tailed Wilcoxon Matched-Pairs Signed-Ranks Test showed no significant difference in points for approach times ( $T = 4$ ,  $P > 0.05$ ).

#### 2.2.6 DISCUSSION

The results do not appear to confirm the earlier predictions and the immobility hypothesis seems to be an inadequate explanation for the different findings using the different test methods. However, in conducting Experiment 2, two times were recorded for each trial:

- (i) the time from lifting the start box door to the animal's reaching of the centre door, and
- (ii) the time from reaching the centre door until the rat had retreated back into the start box again.

Consideration of the problem, and familiarity with the test procedure revealed that these dependent variables were inappropriate. As stated previously, both approach and retreat responses are involved in the dominance tube test, but it is useful to add a third behavioural category, that of waiting at the centre door. The immobility hypothesis states that this waiting period is a longer one for isolated than for grouped animals.

In normal dominance tube encounters the following sequence of events takes place. The start box doors are opened and the animals move forward. If one animal is first to the centre it must wait until the arrival of its opponent before the centre door is opened. If the opponent reaches this point first, it must wait. When both animals are waiting either side of the centre door, the door is lifted and the contest



effectively begins. Then it is the animal which is first to enter its own start box which is the loser. Assuming no significant difference in either approach times or retreat times, a significant difference in competitive success could be obtained as a result of a difference in waiting times.

This could have been manifest in the retreat times of Experiment 2, since these reflect sums of the waiting times plus the times to re-enter the start box. However, the observation (Syme, 1972) that the ultimate losers often make several partial retreats followed by rushes forward before making a complete retreat back to the start box may be relevant. The difference in initial retreat latencies may be relevant insofar as one animal beginning to move backwards may continue to do so as its opponent approaches. A third experiment was conducted in order to examine this possibility.

## 2.3 EXPERIMENT 3

### 2.3.1 SUBJECTS

The subjects were 14 male hooded rats (Otago Strain NZBWS) caged at weaning (21 days). One group of seven animals was placed in a cage measuring 0.75 x 0.33 x 0.45m high, and the remaining 7 were individually housed in metal cages measuring 0.18 x 0.18 x 0.18m high. Ad lib food and water were available, and a reversed light/dark schedule was maintained.

### 2.3.2 APPARATUS

As for Experiment 2.

### 2.3.3 PROCEDURE

At 100 days the tails of the rats were dyed to enable individual recognition, and the subjects were placed on a 23 hour water deprivation schedule. After 7 days deprivation experience, and prior to the daily drinking period, each animal was given a 10 minute period alone in the dominance tube with all doors open and water available at each end. Following this, 8 days of pre-test training were given consisting of six daily trials, three from each end as in Experiment 2. One day of testing was then conducted. The centre door was closed and the animals were given three trials from each end. Times from opening the start box door to

- (i) reaching the centre door;
- (ii) begin retreating (i.e. step backwards with all four legs); and
- (iii) retreating right back to the start box,

were recorded. Thus waiting times could also be calculated by subtracting the first time recorded from the second.

When an animal had retreated to the start box, the centre door was opened and the subject was allowed to traverse the runway and drink for 10 seconds in the goal box at the opposite end.

### 2.3.4 RESULTS

Three different times were compared:

- (i) time from lifting the start box door until arrival at the centre door;
- (ii) time spent waiting at the centre door until the first retreat;

(iii) time from arrival at the centre door until complete retreat back into the start box.

(i) and (iii) were the times recorded in Experiment 2.

For each subject of each housing condition times obtained were compared with each subject of the alternative housing condition. The results thus obtained were treated similar to those of Experiment 2. Scores for grouped animals only were then considered. By chance 50% of the pairings would be expected to yield longer times for these animals than for their isolated counterparts. The results were compared with this chance expectancy using a two-tailed Wilcoxon Matched-Pairs Signed-Ranks Test. Approach times showed no significant difference ( $T = 1$ ;  $P > 0.05$  ( $N = 6$ , 1 draw)). However, the grouped animals had a significant number of shorter waiting times than expected by chance ( $T = 0$ ;  $P = 0.02$ ). Similarly, their retreat times were shorter than their counterparts' significantly more frequently than would be expected by chance ( $T = 1$ ;  $P < 0.05$ ). Because of the ipsative nature of the data it can thus be concluded that, for isolated animals, both the waiting times and the retreat times were longer than their opponents' significantly more often than would be expected by chance.

#### 2.3.5 DISCUSSION

The lack of any significant difference in approach times confirms the findings of Experiment 2 with females. In this respect the results of both experiments appear to contradict the immobility hypothesis. On the other hand, there was a significant difference in the times spent waiting until the initial retreat, and this difference was in the expected

direction. Thus immobility may be a reaction to novel aspects of the test environment, in which case these two findings are not necessarily inconsistent.

In both experiments, prior to the final test day, each animal had nine days in which to become familiar with the apparatus. The tenth day differed insofar as the animals encountered the guillotine doors for the first time. These doors were thus novel stimuli which the rats encountered both before they began to approach and before they began to retreat. The difference lies in the fact that, prior to their approach, the novel stimulus was removed, whereas prior to their retreat it was not. Hence, if immobility is affected by novelty a greater effect would be expected at the centre of the runway than at the start. Archer (1970) reports that an inhibition of exploratory behaviour due to fear-responses such as freezing seems to occur when the change in stimulus conditions is considerable. He writes of reactions to novel situations, "If an animal has been living under conditions of low sensory stimulation (e.g. isolation) the change in stimulus conditions will be relatively large... Possibly isolated animals exhibit fear responses in the test situation mainly because of a relatively large change in the stimulus properties of the environment." Such differential reactivity to novelty between isolated and grouped animals may explain the results obtained in the present study.

The difference obtained in complete retreat times would not have been predicted from Experiment 2, particularly in view of Archer's (1969) findings. His study suggests that the effects of isolation may be greater for females than for males. The present study indicates the reverse, but the two

experiments are not strictly comparable. The subjects from Experiment 3 had no prior experimental experience, whereas those for Experiment 2 had been subjects of Experiment 1 which gave them a good deal of time to become familiar with various aspects of the procedure common to both experiments, such as removal from the home cage and handling. Reaction to such factors probably contributed toward the difference obtained in Experiment 3.

The collective findings of Experiments 2 and 3 present no clear-cut conclusion. Experiment 3 demonstrated that the results obtained in dominance tube studies cited in the literature could be due to purely non-social factors.

Upon reflection it may have been worthwhile conducting dominance tube tests in the usual manner, recording the trials as in Experiment 3. In this way it could have been more easily shown just what part the different behavioural responses play in determining the probability of success.

In conclusion, this series of experiments has demonstrated that, in determining the effects of independent variable manipulation upon competitive success, the conclusions are wholly dependent on the nature of the competition. For this reason the use of arbitrary competitive tests as measures of dominance (understood globally) is unjustified. If a global concept of dominance is retained we are faced with two alternatives: either, (i) some specific form(s) of competitive test must be demonstrated to be a valid measure of dominance, or (ii) an alternative means of measuring dominance must be found.

The problem with the first possibility is the inadequate theoretical basis for selecting tests, or for preferring one

test over another where they yield different results. Some may be rejected through lack of internal validity, but this approach promises much tedious research before the use of standardized competitive tests becomes a reality. This alone is enough to make the second alternative more appealing.

Where there is a lack of correspondence between the various priority measures, Van Kreveld (1970) says the outcome of aggressive encounters is the appropriate index of dominance. Aggression indices are the most widely used alternatives to competitive tests, but there are problems peculiar to this measure which have been discussed in the previous chapter. General use of the measure is not defensible on either pragmatic or theoretical grounds. An alternative to the aggression index is the grooming index suggested by Spigel and Fraser (1974). The next chapter deals with this index.

### CHAPTER THREE

#### A RE-ANALYSIS OF GROOMING AS AN INDEX OF DOMINANCE IN RATS

It is evident from the preceding chapter that there are serious shortcomings in the use of competitive tests as measures of dominance. If dominance is to be retained as a useful explanatory concept there must be a clearly-defined means of measuring dominance relations. Spigel and Fraser (1974) suggest the grooming index as an alternative to the use of competitive tests: the present study examines this index.

#### EXPERIMENT 4

##### 3.1 INTRODUCTION

Spigel, Trivett and Fraser (1972) introduced social grooming as a measure of dominance in rats. These authors regard a rat which grooms another more than it is groomed itself as the dominant animal of the pair; the rationale for their use of the grooming index being a high correlation found between initial performance on a water-competition task and later measures of social grooming. Not only was it observed that the dominant animals on the water-competition test groomed submissive animals more than they were groomed, but also that they spent a greater proportion of time grooming than would have been expected from the water-competition data.

Although the relationship between grooming and

competition reported by Spigel et al (1972) was high, and the grooming index has certain procedural advantages, there are a number of unsatisfactory aspects of their study. Firstly, the investigation was based on the authors' hypothesis that rats fight in order to obtain a grooming right over their fellows and that grooming is an antecedent to aggression.

In order to demonstrate this however, instead of experimentally relating aggression and grooming behaviours they chose to examine the relationship between grooming and social dominance as measured in a water-competition situation. While adopting this line of experimentation these authors appear to have overlooked the study by Baenninger (1970) which found food, water and aggressive orders in the rat to be poorly correlated. Syme et al (1974) have also shown that limited access water-competition orders fluctuate with small changes in the required competitive response. Thus, on the basis of this literature, all that can be concluded from Spigel et al (1972) is that social grooming apparently correlates with one specific measure of water competition. It has not been shown that aggression results from a need to groom as they suggest, nor has the generality of the grooming measure been demonstrated.

Barnett's 'Study In Behaviour' (1967) presents further difficulties to the interpretations of Spigel et al. Barnett describes grooming as one of a number of stereotyped contact behaviours "which may be called 'amicable': they are directed at other rats and they are the opposite of aggression". While the strains of rat used differed, nonetheless, Barnett's analysis of the grooming response is important insofar as it relates to the generality of a grooming index



of social dominance.

Spigel et al suggest that grooming is a stronger and more consistent index of social dominance than is water competition. However, they appear to have overlooked the fact that the results presented are those of animals recorded as being dominant on the grooming index. Thus, in the comparison made there is a bias towards this index. The results of those animals recorded as being ascendent in water competition should be independently analysed before a valid comparison can be made.

A major procedural objection can also be directed at Spigel et al (1972). In order to demonstrate the correlation between grooming and water competition these authors presented the experimental conditions in a water competition - grooming - water competition order only. However, in view of the Baenninger (1970) and Syme et al (1974) studies it may well have been that the relationship observed between the water competition and the grooming order was due to a transfer effect from water competition to grooming. If this is the case the grooming index would always have to be preceded by a competitive measure, which would render it impractical as a dominance test. Hence an appropriate control for the Spigel et al study would have been social grooming - water competition - social grooming. If a high relationship between social grooming and competition was observed under these conditions, a more valid basis for the use of social grooming as a dominance index would have been obtained. The present experiment is a repetition of that done by Spigel et al (1972) with the addition of the reverse order of experimental conditions.

### 3.2 METHOD

#### 3.2.1 Subjects

The subjects were two groups of 16 male hooded rats (Otago Strain NZBWS) aged approximately 150 days at the beginning of the experiment. All animals had been housed individually since weaning (21 days) and they were maintained on a reversed light-dark schedule. Ad lib food was provided. In each group the animals were paired randomly, and these pairs retained throughout the experiment, although the rats continued to be housed individually.

#### 3.2.2 Apparatus

Two separate test chambers were used.

**Water Competition:** This was a metal box measuring 33 x 33 x 33 cm, which was illuminated by four 10W bulbs mounted in a unit in the roof. A perspex door formed one side of the apparatus and permitted direct observation of the subjects. The remainder of the apparatus was painted white. In one wall there was a recess at floor level. A hole in the floor of the recess allowed the animals to drink from a water trough outside the chamber. The dimensions of the recess (diameter 3cm, depth 2cm) were such that only one animal could drink at a time.

**Grooming:** The grooming arena was a box measuring 61 x 61 x 25.4 cm, which was painted dark brown. Illumination was provided by a 40W fluorescent tube suspended 1 m above the centre of the field.

#### 3.2.3 Procedure

**Group 1:** The subjects were habituated to the grooming arena individually for four days for 3 min/day, after which social-grooming testing began. Four days of grooming testing

then followed. During this time the subjects were placed in the grooming arena in pairs for 10 min/day and the amount of time each rat spent grooming the other recorded. As in Spigel et al (1972) only the gross manifestations of grooming dominance were recorded and these were, in this case, the actual "chewing like" movements at the back of the head and the genital area and those occasions in which one rat detained another by pushing or holding in order to lick or groom it.

The subjects were then placed on a 22 hour water deprivation schedule and were habituated individually to the competition apparatus for 3 min/day for 10 days. During habituation a record was kept of the time spent drinking by each subject. Four days of water competition then followed. The competitive encounters were conducted over 1-min. periods since the average time/subject spent drinking on the final day of habituation was only 64.4 sec. Competitions were conducted once daily for each pair.

The amount of time each rat maintained control of the water trough was recorded for each session. Each day following competitive testing the animals were provided with water in their home cages for 2 hours. After the fourth day of competition the rats were again provided with ad lib water and a final 4 days of social grooming were observed in the same manner as the first 4 days.

Group 2: The procedure was reversed. Thus Group 2 was subjected to the same order of conditions as that employed by Spigel et al - a familiarization period of 10 days with 3 min daily sessions in the competitive apparatus was followed by four daily sessions of water competition.

Immediately following each competitive period, each subject was permitted a 3 min. familiarization period in the grooming arena. Four days testing of social grooming followed and a further four days of water competition. The competitive periods were as for Group 1.

### 3.3 RESULTS

These were analysed in two distinct ways.

#### 3.3.1 Method 1

As in Spigel et al (1972) the member of each pair which groomed its partner more than it was groomed itself over the first block of social grooming trials were designated the "dominant" animal of the pair. For the dominant animal of each pair recorded data was converted into percentages of total time spent drinking or grooming respectively for that pair.

Group 1: These percentages for the "dominant" animals over the three phases of testing may be seen in Figure 1a. It is obvious that the "dominant" animals on the first phase of grooming did not perform better in the competitive phase than would be expected by chance.

The details of the performance of each pair may be seen in Table 1; here it can be seen that 4 of the 8 animals which were dominant on the original grooming measure were defeated in water competition - again a chance occurrence.

In order to quantify the reliability of the grooming relationships over the period between the first and second grooming observations a Wilcoxon matched-pairs signed-ranks test was calculated between the performance of the "dominant"

animals on the second grooming test and the chance value of 50%. The resultant value ( $T = 2$ ,  $P < .01$ , one-tailed) proved to be significant, demonstrating that the grooming index was reliable over the competitive testing period.

Group 2: The transformed results for "dominant" animals may be seen in Figure 1b. These animals do not appear to have done significantly better or worse than chance in the two blocks of competitive testing. Table 2 shows that 3 of the 8 animals which were dominant on the grooming measure were defeated in water competition. Wilcoxon matched-pairs signed-ranks tests showed "dominant" animals did not perform significantly better than chance in either the initial ( $T = 18$ ,  $P > 0.05$ ) or final ( $T = 16$ ,  $P > 0.05$ ) block of competitive testing. Observed performances were compared with the expectancy of 50% for each "dominant" rat.

### 3.3.2 Method 2

The member of each pair which spent more time drinking than its partner over the first block of competitive testing was designated the "winner".

Group 1: Figure 2a shows the percentage of time spent drinking by "winners" is little different from the percentage of time spent grooming, particularly over the first block of trials. Wilcoxon matched-pairs signed-ranks tests showed "winners" performed no better than would be expected by chance in either the initial ( $T = 7$ ,  $P > 0.05$ ) or final ( $T = 6$ ,  $P > 0.05$ ) grooming phases.

Group 2: Figure 2b reveals little difference in the percentage time "winners" spent drinking over the final phase and that spent grooming. The average percentage time

spent drinking over the initial trials is higher than both these. However, there is high variability over this phase. A Wilcoxon matched-pairs signed-ranks test showed that "winners" did significantly better than chance over the grooming trials ( $T = 4$ ,  $P < 0.05$ ) two-tailed). A similar test was employed to check the reliability of the competitive measure over the grooming phase. The measure proved unreliable ( $T = 11$ ,  $P > 0.05$ ).

### 3.4 DISCUSSION

The high relationship between social grooming and water competition performance observed by Spigel et al (1972) was not demonstrated in the present study. Four out of eight "dominant" animals for group 1 and 3 out of 8 for Group 2 were defeated in water competition. While the social grooming observations bore no relationship to the competitive measures they did prove reliable over the period during which competitive experimentation was carried out for Group 1. In contrast the competitive measure for Group 2 proved unreliable over the grooming trials. This lack of reliability is reflected in the variability of percentages of time spent drinking seen in each of the four curves.

While there is thus support for Spigel et al's assertion that the grooming index may be more consistent, the difference between the two indices is too small to support the claim that the grooming index is the stronger. Mean percentage times for dominant animals over each block of grooming trials were 70.9 and 77.0 for Group 1, and 61.3 for Group 2. Mean percentage times over each block of competitive trials were 63.2 for Group 1 and 72.6 and 57.9

for Group 2. There is little value in comparing the relative strengths of the two indices. The present study suggests they are not measuring the same thing.

The precise reason for the difference between the two studies cannot be determined from the experiment. However there are four possible alternatives:

- (1) Once the grooming relationships are stabilized they are not affected by water competition. However, where the initial encounter is in the competitive setting, the grooming relationship may be partially developed prior to testing in the grooming arena.
- (2) The grooming order may relate to performance in the competitive apparatus used by Spigel et al, but not to that used in this study (Syme et al, 1974).
- (3) The relationship between grooming and competition could be high when a 3-min. competitive period is used but not when another competitive period is chosen (Bruce, 1941).
- (4) A high relationship between grooming and water competition may occur only for the Wistar strain of rat.

It is of little consequence, though, as to which or whether all of these possible factors contributed to the difference. Any one of these explanations makes it clear that the use of social grooming as a general measure of social dominance in the rat is unjustified.

Regardless of the outcome of the present experiment the use of social grooming as an experimental measure of social dominance has a major procedural drawback. In order to create a competitive situation for social grooming the rats must be

deprived of the opportunity to groom other animals prior to testing. Hence, only isolated rats can be used. This is a severe limitation in that many experimental studies are interested in dominance relationships in a group situation.

In conclusion, therefore, it can be seen that the use of social grooming as a measure of dominance in the rat must be reconsidered. The hypothesis advanced by Spigel et al (1972), that rats have a "need" to groom which results in aggression is not supported by the experimental evidence available (Baenninger, 1970; Syme et al, 1974); water competition has not been shown to correlate with aggressive behaviour in the rat. In the absence of such data Barnett's (1967) description of social grooming as an "amicable" behaviour must be regarded as an equally viable alternative.



Tables 1 and 2: The animal of each pair which gained the higher proportion of the grooming or competitive times.

D - those animals which were "dominant" on the first grooming observations. S - those animals which were "submissive" on the first grooming observations.

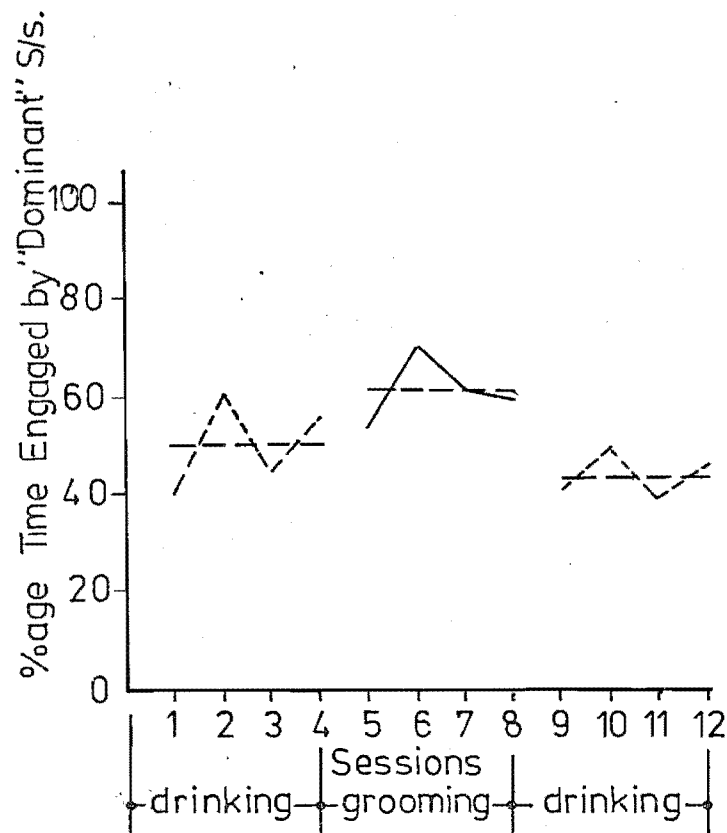
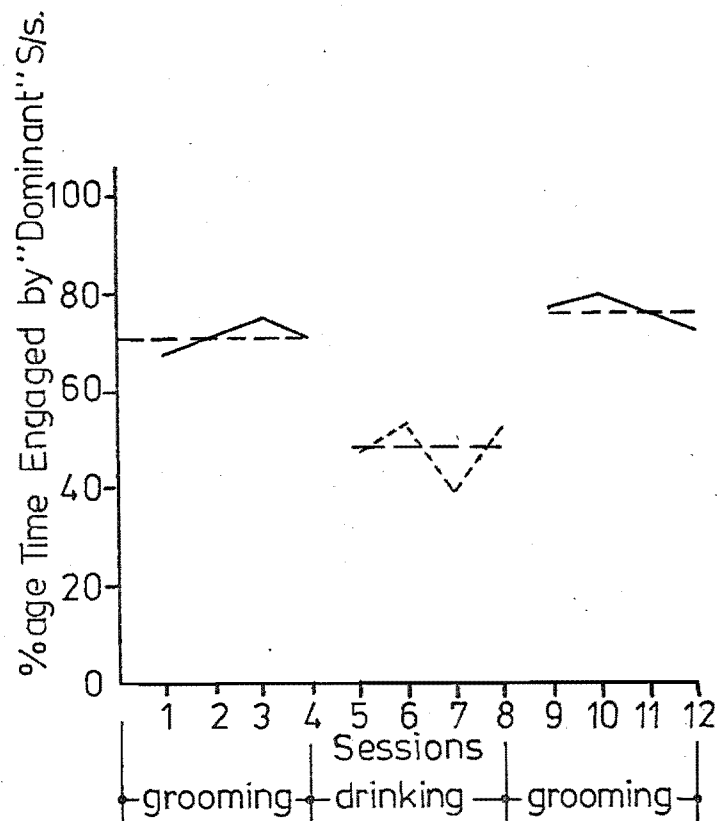
TABLE 1: GROUP 1 PAIRS

<u>Pair</u>	$G_1$	C	$G_2$
1	D	D	D
2	D	S	S
3	D	S	D
4	D	S	D
5	D	S	D
6	D	D	D
7	D	D	D
8	D	D	D

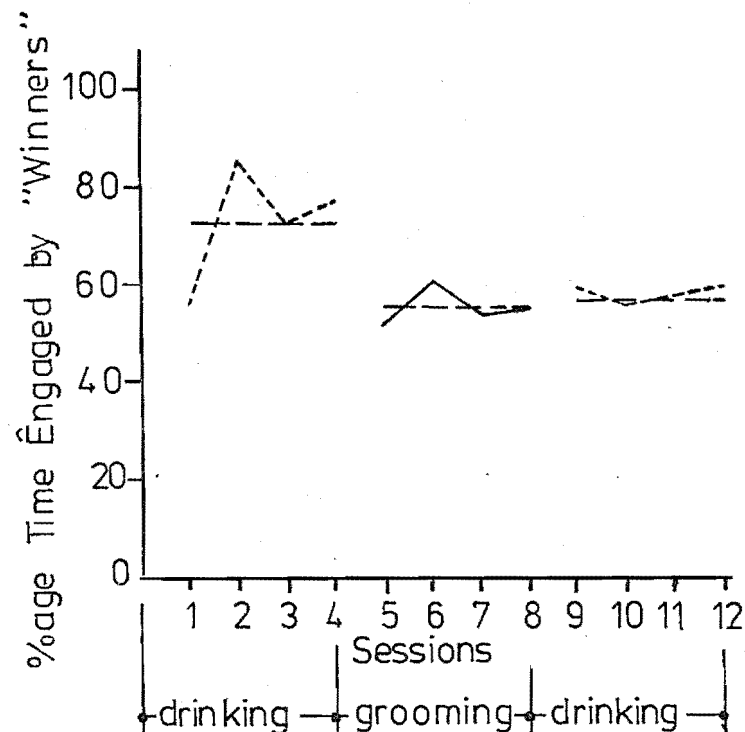
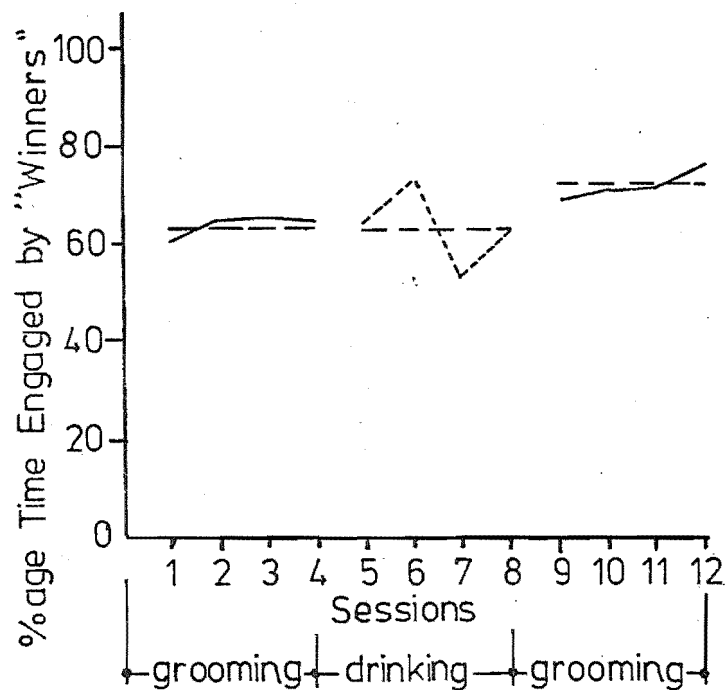
TABLE 2: GROUP 2 PAIRS

<u>Pair</u>	$C_1$	G	$C_2$
1	D	D	D
2	D	D	D
3	S	D	S
4	S	D	S
5	D	D	S
6	S	D	D
7	D	D	D
8	D	D	D

FIGURES 1a and 1b: Percentages of time spent drinking and grooming by "dominant" rats of pairs from the first grooming observations as a function of testing sessions. Data are percentages of total time spent on the particular activity under observation.



FIGURES 2a and 2b: Percentages of time spent drinking and grooming by "winners" of the first block of water-competitive trials as a function of testing sessions. Data again are percentages of total time spent on the particular activity under observation.



## CHAPTER FOUR

### TWO EXPLORATORY EXPERIMENTS

The previous two chapters have illustrated the inadequacy of existing procedures for assessing dominance. The results of competitive tests are dependent upon the nature of the test employed, and there does not appear to be any alternative index. In the absence of such an alternative the present chapter examines competitive testing more closely.

Competitive measures are important on two counts. Firstly, if the concept of dominance is retained, appropriate competitive measures may be used to assess dominance relations. Secondly, standardization of competitive tests is required for studies of competitive behaviour per se. The problem of standardizing competitive measures of dominance is complicated by the absence of a generally accepted definition of the term. The definitional problem is itself a two-sided one: the definition must relate to observable behaviour and in this sense the behaviour is pre-definitional - but the use of the term "dominance" as opposed to some other label is only justifiable if there is some link to its historical usage, and so the definition is (at least partially) pre-behavioural.

The problem addressed here concerns the methodology of competitive testing, but the interrelation of this problem with that of definition suggests that clarification in one area will bring clarification in the other. The intention at this point is to attempt to defend some concept of dominance, however it is competition rather than dominance assessment which is the main subject of this chapter.

While procedural standardization could be achieved within the range of competitive tests reported in the literature, initial investigations involving a deliberate break with these patterns are warranted. Syme, Pollard, Syme and Reid (1974) found different competitive orders where all conditions were constant but for a small change made in the response requirement. This raises questions about other factors which are possibly important. For example, are competitive orders similarly dependent upon location? Or temporal factors? The experiments reported in this chapter have more of an exploratory nature than those previously described. They represent a deliberate attempt to break with the normal limited access procedures, at the same time addressing specific theoretical questions relating to procedural standardization.

#### 4.1 EXPERIMENT 5

##### 4.1.1 INTRODUCTION

Experiment 1 of Chapter 2 indicated one methodological inconsistency in competitive studies involving the typical use of an arbitrary period of familiarization prior to competition. For example, in Experiment 1 a 22 day familiarization was employed, while Hoyenga and Lekan use 1 day. Syme, Pollard, Syme, and Reid (1974) used 10 days. In studies of competitive behaviour the familiarization phase has appeared as a necessary evil. Syme et al (1974) showed the need for baseline measures of performance their study giving the first indication that the pre-competitive phase can generate relevant data. This phase in rats is often

initially characterized by a low level of mobility.

The need for familiarization arises because of the artificial nature of the experiment; either in response requirement, or location, or both. Of the many researchers dealing with competitive behaviour in rats, only Baenninger (1966,70) conducts studies in the home cage. The majority of studies employ at least some isolated subjects, and this has possibly led to the use of external, neutral test sites. Where isolated subjects are not required testing in the home cage has the advantage of eliminating the period of familiarization to the test site, and thus resolving the problem of standardization of familiarization periods. However, this is only possible where intragroup relations are of importance. Where intergroup relations are being studied, testing in one or other of the home cages may influence competitive success, i.e. Success may be location-dependent.

Historically dominance and territoriality have been viewed as different solutions to the problem of resource distribution (Wynn-Edwards, 1965). Since reliable competitive orders have been found in laboratory rats (e.g. Baenninger, 1970) dependence upon location might not be expected. However, many modern writers place territory and dominance on a single continuum, so that Fisler (1969), who reviews a number of papers in this area, writes, "Territory and hierarchy are not different in kind but in degree". Thus, demonstration of hierarchy does not preclude some degree of territoriality. The present experiment was an investigation into the location - dependence of competitive success. Whether such a dependence could demonstrate territoriality is doubtful. Possibly it would be better explained in terms of familiarity

rather than territoriality. Tinbergen (1957) has suggested that territory results from site attachment plus intra-specific hostility. In the absence of overt aggression any ascendance in the home cage might be more parsimoniously attributed to site familiarity alone.

Bolles and Rapp (1965) found that readiness to eat in rats under high levels of deprivation (24 hours) increased with familiarity with the test apparatus. However, the variability of eating - latencies increased significantly with familiarity. In a novel setting Bolles (1962) found the latency of consummatory activity greater for food deprived rats than for water deprived rats. Animals were tested under various levels of deprivation over 6 trials for two successive days. There is no analysis of trends over the 12 trials, but the latencies reported for the first trial of each day suggest a reduction in latencies with increased familiarity, with a converging of eating and drinking latencies. This suggests a relationship between eating and drinking latencies.

The emphasis in other studies has tended to be on eating. For example, Blanchard, Shelton, and Blanchard (1970) found familiarization with the competitive setting to be an important determinant in eating latency and eating times. Familiarized animals had shorter latencies and longer eating times in 5 min. test trials.

These results are to be expected insofar as exploration and both eating and drinking are competing behaviours. Zimbardo and Montgomery (1957) demonstrate this and go on to make the following observation consistent with Bolles' (1962) finding: "Also, the pattern of exploration

and consummatory behaviour differed during the 10 min. tests, thirsty animals tending to drink at first and explore later whereas hungry animals tended to explore first and drink later."

If this is so, site familiarity could be expected to enhance competitive performance especially where food is the reward, although there may be some inconsistency under these conditions (Bolles and Rapp, 1965). Problems with food reinforcement in competitive studies were described in Chapter 2, and for the purposes of this study water was preferred.

#### 4.1.2 SUBJECTS AND APPARATUS

The subjects were 26 male hooded rats (Otago Strain, NZBWS) approximately 130 days old at the beginning of the experiment. These were divided into two groups of 6 animals and two groups of 7 animals housed in four identical wire-fronted galvanized-iron cages measuring 0.33 x 0.51 x 0.31 m. high. Each cage was fitted with a 3cm deep copper arch which covered the drinking tube. The width of the arch (3cm) was such that only one animal could drink from the tube at a given time. Ad lib food was available and a reversed light-dark schedule maintained throughout the experiment.

The subjects were housed in this manner for 28 days before the experiment began. Cages were cleaned weekly until one week before the beginning of the experiment but were left undisturbed during the experiment to enhance site familiarity and avoid the confounding effects of new sawdust on the floor of the cages. When sawdust is replaced increased play and general activity is regularly observed in the rat colony.



#### 4.1.3 METHOD

Seven days before experimentation began the S's were placed on a 23½ hour water deprivation schedule. On the seventh day each group spent 15 min of their 30 min drinking period in the home cage, and 15 min in the cage of the other group of equivalent size ('Away' cage). The following two days each animal was individually tested for weight of water consumed and time spent drinking. A 2 min. test period was used. Half the animals from each group were tested in the home cage first (day 8) and then the away cage (day 9), while for the remainder the conditions were reversed.

For each group the total weight of water consumed by each animal was calculated and ranked by measuring the weight gained over each of these two sessions. Each animal was paired with the animal of equivalent rank in the group of corresponding size.

Competition was conducted over the following two days with little change to the procedure apart from the fact that the animals were tested in their respective pairs. One of each of the pairs of cages was used on the first day of competition, the other on the following day.

#### 4.1.4 RESULTS

In the analysis of the results a problem arose from the ipsative nature of competitive scores. This problem, which was referred to in Chapter 2, invalidates the statistics employed in several studies in the literature and has been subsequently dealt with by Syme and Doak (1974, see Appendix). To overcome it each pair of animals was regarded as a unit

and the percentage of total time spent drinking which was spent in the home cage condition was calculated. Weights gained in competition were similarly treated and the results are presented in Table 3. The chance expectancy is for the home cage condition to contribute 50% of the total time and total weight gain.

The obtained percentages were compared with this chance expectancy using a two tailed Wilcoxon Matched-Pairs Signed-Ranks Test. Both time spent drinking ( $T = 12$ ,  $P < 0.02$ ) and weight ( $T = 16$ ,  $P < 0.05$ ) showed that rats perform significantly better in the home cage.

Results for the pre-competitive phase were similarly analysed (Table 4) with subjects being treated in their competitive pairs. Levels of performance in the home cage for times ( $T = 25.5$ ,  $P > 0.05$ ) and weight ( $T = 40.5$ ,  $P > 0.05$ ) were not significantly different from the chance expectancies.

#### 4.1.5 DISCUSSION

While the home cage facilitated competitive performance, it is not clear whether social factors contributed, particularly in view of the studies reviewed above. Considering these reports, the results of the pre-competitive phase are surprising. However, the home cage/away cage conditions do not simply provide familiar and unfamiliar environments. Competitors were unfamiliar under both conditions. The novelty of the other competitor added to the novelty of the cage may have been sufficient to negatively affect drinking behaviour in the 'away' condition, relative to the 'home' condition. No assumption can be made that the stimuli provided by the opponent were qualitatively different from other unfamiliar

aspects of the environment. No overt aggression as generally characterizes territorial behaviour was observed in subjects under either condition.

If familiarity with the test site enhances competitive performance, questions arise about the validity of studies where the degree of familiarization is relatively low. Assuming a range in responsiveness to novelty, relative position within a group may depend upon amount of habituation. The effects of independent variable manipulation may be distorted by interactions with the effects of the location of competition. The design of the present experiment may have magnified the home cage effect by comparing performance in the home cage with performance in the competitor's home cage, rather than intra-group relationships in the home cage versus a neutral test site. On the other hand, the two test sites were very similar, and subjects had extensive experience with most aspects of the limited access setting. In the literature, response requirements in the competitive context have not always resembled those required under normal housing conditions. Tests may therefore be measuring the ability of subjects to acquire a new skill; causing rather than measuring given relationships.

The principal value of this study lies in its exposure of specific problems, some of which have been dealt with above. However, one further methodological consideration remains. In order for individuals or pairs to be tested, non-competing animals had to be removed and placed in neutral cages. This treatment probably reduced the home-cage effect, especially in the pre-competitive phase. The overwhelming majority of studies in the literature employ a

paired-comparisons procedure using either fixed or rotated pairs. The widespread adoption of this technique has probably been one of the most significant factors leading to the use of neutral test sites. In order to obtain a hierarchy with a group, all possible pairings must be observed. Thus rotated rather than fixed pairs must be used. However, Becker and Ezinga (1969) question the use of rotated pairs on the basis of possible interactions between:

- (a) the experimental manipulation and serial effects based on stimulus generalization (Becker, 1965); and
- (b) sampling error and serial effects based on stimulus generalization (Seward, 1946).

Whether fixed or rotated, the use of pairs to discover intra-group relationships has not been validated. This is particularly important insofar as it is tacitly assumed that the sum of the dyadic relationships accurately describes the social structure of the group.

The technique may in fact mask important aspects of group competition, for example, sequences of behaviour within group competition. A simple hierarchy presented on the basis of paired encounters could be interpreted a number of ways. From a hierarchy derived from water competition it could be inferred that number 1 drinks until satiated, followed by number 2 which does likewise and so on in orderly fashion. Alternatively, the hierarchy may reflect order of first appearances.

e.g. S1 → S2 → S1 → S2 → S3 → S1

A third possible interpretation is that over the entire competitive period S1 will have spent more time drinking than

S2, S2 more than S3, and so on. This may depend upon the dependent variable in the particular competitive test from which the hierarchy was derived.

Experiment 6 was conducted in an attempt to depart from the paired-comparisons method and to more closely examine sequences of drinking within water competition.

## 4.2 EXPERIMENT 6

### 4.2.1 INTRODUCTION

Obvious advantages of a paired-comparisons procedure are the easy identification of subjects, and the relative ease of measuring the dependent variable. Oldfield - Box (1969) measured the total time each member of groups of three competitors ate from a single food pellet. Baenninger (1966, 1970) was able to measure the time the food or water source was controlled by each subject from groups of four animals. With pairs of animals two stop-clocks can be manually operated, but with a greater number, time is more difficult to measure. Similarly, pre and post-test weighing of subjects to estimate weights consumed poses problems. The greater time required for the operation means an increased likelihood that animals will urinate or defecate and so give erroneous results.

Bolles and Rapp (1965) recorded individual S's behaviour using a keyboard with each switch corresponding to one behavioural category. In the present study a keyboard was connected to an operations recorder. Each key corresponded to one subject. Thus a continuous record could

be kept of which animal drank from a limited access water-source. Even using this device the demands upon the experimenter are high. Subjects must be instantly identified and the corresponding response key pressed until drinking stops. Identification of subjects is complicated by the heaping of subjects at the reward source, thus obscuring identification dye. The copper archways limiting access in Experiment 5 further compound the problem by hiding ear marks. Faced with these difficulties the group in the present study was restricted to four animals.

#### 4.2.2 SUBJECTS

S's were 4 male hooded rats (Otago Strain NZBWS) approximately 150 days old at the beginning of the experiment. They were housed in a 0.33 x 0.51 x 0.31 m. high metal cage identical with those used in Experiment 5. As in the previous study the cage was fitted with a copper arch providing a limited access to the drinking tube. The S's were dyed to enable individual recognition.

#### 4.2.3 APPARATUS

Apart from the home cage already described, the only other apparatus was the operations recorder with four response keys.

#### 4.2.4 METHOD

Before any deprivation the subjects lived for one month in the cage described in which water was available at

the drinking tube 24 hours per day. After this period the subjects were placed on a 23½ hour water deprivation schedule and for 14 days drinking responses were recorded over approximately the first 10 min. of each 30 min. session where water was available. A drinking response was defined as licking from the water tube. The sequence and duration of drinking responses were recorded. This served as training for the experimenter in identifying subjects and in monitoring responses. At the completion of this training phase the experimental sessions began. Again the first 10 min. of each drinking session were observed and drinking responses were recorded. Data were collected for sixteen days although this phase took longer than this, some data being lost through failures on the part of the experimenter, and of the equipment.

#### 4.2.5 RESULTS AND DISCUSSION

Variation in the experimenter's response times meant a certain amount of error was inherent in the method. For this reason the length of drinking responses or drinking 'bursts' were classified according to categories with 2 sec intervals, i.e. 0 - 2 sec., 2 - 4 sec., 4 - 6 sec., etc. Data were analysed both in terms of the number of these bursts, and the total time spent drinking. Results were divided according to the ten 1 minute periods making up one experimental session. This enabled trends within the sessions to be examined. Results are presented in Tables 5 to 8, and Figures 3 to 5. Once more, caution is required in the interpretation. The measures are ipsative on two counts: first, insofar as a high time score by one subject means a lower possible score for the remainder; and second, insofar as

a single sustained burst by one animal means a lower possible frequency for both that subject and the remainder. A further complication is due to the absence of motivational control. In fact, it was clear from the behaviour of the competitors that motivation decreased markedly within the 10 min. sessions. This is reflected in Table 5.

The total number of bursts in the 10th minute is little more than half that of the preceding minutes. At the same time the total drinking times for the last 4 minutes are higher than for the first 6. This is because drinking in the early stages was characterized by a high percentage of short bursts of 2 seconds or less duration. Control was lost and regained many times, leading to the loss of much drinking time. As the more successful animals became satiated the intensity of competition was reduced and bursts tended to be fewer and longer.

The performance of individual subjects are depicted in Figure 3. The separation between each pair of lines indicates the amount longer bursts contributed to the total time. Graph 1 shows R1 beginning with a high level of success which is maintained until about the 6th minute. R2 (Graph 2) fared poorly in the first minute but thereafter maintained a fairly constant drinking time, although the number of bursts decreased over the final 2 minutes. Total drinking time for R3 yielded a clearly bimodal distribution, peaking in the first and seventh minutes. The number of bursts on the other hand remained fairly constant until the decline near the end of the 10 mins. R4, while maintaining a fairly constant number of bursts throughout the whole experimental period, showed a great increase in times spent drinking for the last 4 minutes, peaking at the 10th minute.



Absolute drinking times were ranked and used to represent competitive success in Figure 4. Each rat's performance relative to the rest of the group is seen in Table 5. The number of bursts each minute were similarly ranked and represented in Figure 5. Performance relative to the rest of the group is seen from Table 8.

Time spent drinking is the most commonly used indicator of success in water competition in the literature. With this measure R3 appears to be most successful over the first minute, followed by R1 for 5 mins, R3 for a further minute and R4 for the final 3 mins. At no stage is R2 the most successful. However, the mean ranks are 1.8, 3, 2.3 and 3 for R1 - R4 respectively. While these ranks show no difference between R2 and R4, the individual graphs suggest that R2 is the more successful competitor. On the basis of these graphs and the other data presented, the competitive success could be ranked in the following order:

R1 —————> R3 —————> R2 —————> R4

Nevertheless it is clear both from the behaviour observed during competition and from the data presented that this order merely reflects probable competitive success over a certain time period. A competitive period which is too long may merely reflect differences in drinking capacity (Syme et al, 1974). In the present group, had a 15 min. test period been used and total times spent drinking compared over the entire period, R4 could well have appeared the most successful. This study suggests a constraint is similarly required in the opposite direction. Had a 1 min. test period been employed R3 would have appeared more successful than R1. At no stage did one animal monopolize the water

source, and the first minute particularly was characterised by much free-for-all activity. Figures 4 and 5 both give the same order for the second minute as that suggested for the group overall. By the tenth minute both measures yielded precisely the reverse order.

Of the two measures the time spent drinking appeals as the more valid indicator of drinking performance. This is quite clear from the results that might be predicted from an extremely successful competitor. Such an animal might always drink first and continue drinking until satiated. Thus the number of bursts per session would always be one, and the ranking probably lowest in the group.

The large number of short bursts exhibited by all rats (Table 6) supports a non-social interpretation of competition. Performance seems to be related to competitive skill rather than social status. On the other hand, the more stable order coming from the second minute to the sixth or seventh (where motivational changes are probably important) might be seen as consistent with some kind of social assertion. In view of the continuing high number of short bursts (Table 5) this seems unlikely.

#### 4.3 CONCLUSION

These two experiments were exploratory studies designed to depart from the traditional limited access procedures. Hopefully, by such departures discovery of relevant parameters will reduce the number of ad hoc stipulations which will probably follow standardization of competitive procedures.

Experiment 5 suggests that location of competition

may be an important determinant of position within the group. More work is required before firm conclusions can be drawn, but it is suggested that in studies involving competition in neutral test sites there may be confounding due to individual differences in reactivity to novelty. Where intragroup relationships are being studied it may be best to test in the home cage with all members competing simultaneously, thus avoiding both this problem and those associated with paired-comparison procedures. This was the approach in Experiment 6. Where group competition is observed, baselines such as those suggested by Syme et al (1974) may be difficult to obtain. In such circumstances results may be treated cumulatively (see Chapter 5). While temporal changes in overall ascendancy as found in Experiment 6 may thus be demonstrated, there appear to be no external criteria for the length of the competitive period.

TABLE 3: RESULTS FOR EACH PAIR OF ANIMALS IN THE COMPETITIVE  
PHASE OF EXPERIMENT 5.

PAIR	Total Time Spent Drinking in Seconds		Percentage of Drinking Time in Home Cage	Total Weight of Water Consumed in Grams		Percentage of Weight Consumed in Home Cage
	Home	Away		Home	Away	
1	134	89	60.1	5.2	5.0	51.0
2	125	97	56.3	6.8	4.8	58.6
3	71	142	33.3	3.2	5.7	36.0
4	124	94	56.9	6.1	4.9	55.5
5	135	73	64.9	5.8	4.4	56.9
6	131	73	64.2	6.8	5.3	56.2
7	159	67	70.4	7.5	5.7	56.8
8	117	86	57.6	7.5	5.4	58.1
9	139	91	60.4	7.2	5.7	55.8
10	109	107	50.5	6.9	5.9	53.9
11	144	86	62.6	7.8	5.4	59.1
12	155	122	56.0	7.8	7.4	51.3
13	156	149	51.2	6.0	6.8	46.9

TABLE 4: RESULTS FOR EACH PAIR OF ANIMALS IN THE PRE-  
COMPETITIVE PHASE OF EXPERIMENT 5.

PAIR	Total Time Spent Drinking in Seconds		Percentage of Drinking Time in Home Cage	Total Weight of Water Consumed in Grams		Percentage of Weight Consumed in Home Cage
	Home	Away		Home	Away	
1	240	240	50.0	9.7	9.0	51.9
2	238	204	55.1	7.9	8.7	47.6
3	234	236	49.8	8.9	8.8	50.3
4	230	215	51.7	7.1	7.5	48.6
5	239	240	49.9	9.1	7.2	55.8
6	235	234	50.1	7.7	7.1	52.0
7	239	239	50.0	10.4	9.9	51.2
8	196	227	46.3	8.5	8.6	49.7
9	240	201	54.4	9.5	6.5	59.4
10	213	190	52.9	7.2	7.9	47.7
11	189	213	47.0	7.2	6.8	51.4
12	175	177	49.7	6.5	6.8	48.9
13	220	202	52.1	5.3	6.7	44.2

TABLE 5: GENERAL SUMMARY TABLE: NUMBER OF BURSTS OF DIFFERENT LENGTHS IN EACH MINUTE OF COMPETITION.

	DURATION OF BURST IN SECONDS											TOTAL NO. OF BURSTS	TOTAL DRINKING TIME IN SECONDS
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22		
1	462	27	1	0	0	1	0	1	0	1	1	494	614
2	526	17	3	2								548	606
3	549	21	1									571	617
4	534	21	1	1								557	609
5	524	26	1									551	607
6	471	24	4	2	1	0	0	1	0	1		504	620
7	477	34	10	2	1	0	0	2	0	0	2	528	724
8	392	55	7	0	2	0	0	1	1	2	2	462	724
9	342	41	8	9	2	4	3	3	0	0	1	413	737
10	244	25	6	7	0	3	2	0	2	1	5	295	699
TOTAL	4521	291	42	23	6	8	5	8	3	5	11		

TABLE 6: TOTAL NUMBER OF TIMES EACH SUBJECT GAINED CONTROL OF THE WATER SOURCE VERSUS LENGTH OF "BURST"

		0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>20
SUBJECT	S1	1418	94	9	4	1	1	1	1	1	1	2
	S2	1035	51	9	5	2	1	0	2	0	2	1
	S3	1088	89	11	5	1	3	2	3	0	2	4
	S4	980	57	13	9	2	3	2	2	2	0	4

TABLE 7: TIME SPENT DRINKING EACH MINUTE

	Proportion Contributed By Each Animal									
	Minutes									
	1	2	3	4	5	6	7	8	9	10
R1	.35	.34	.36	.32	.35	.35	.25	.24	.25	.14
R2	.08	.22	.24	.24	.22	.28	.23	.21	.20	.20
R3	.38	.27	.21	.24	.23	.21	.31	.27	.24	.21
R4	.18	.16	.19	.19	.23	.16	.21	.28	.31	.46

TABLE 8: NUMBER OF BURSTS EACH MINUTE

	Proportion Contributed By Each Animal									
	Minutes									
	1	2	3	4	5	6	7	8	9	10
R1	.42	.35	.36	.32	.34	.35	.27	.20	.23	.20
R2	.09	.23	.24	.25	.22	.23	.26	.27	.22	.24
R3	.28	.27	.21	.24	.23	.22	.26	.26	.26	.22
R4	.21	.16	.19	.19	.21	.20	.21	.26	.29	.33

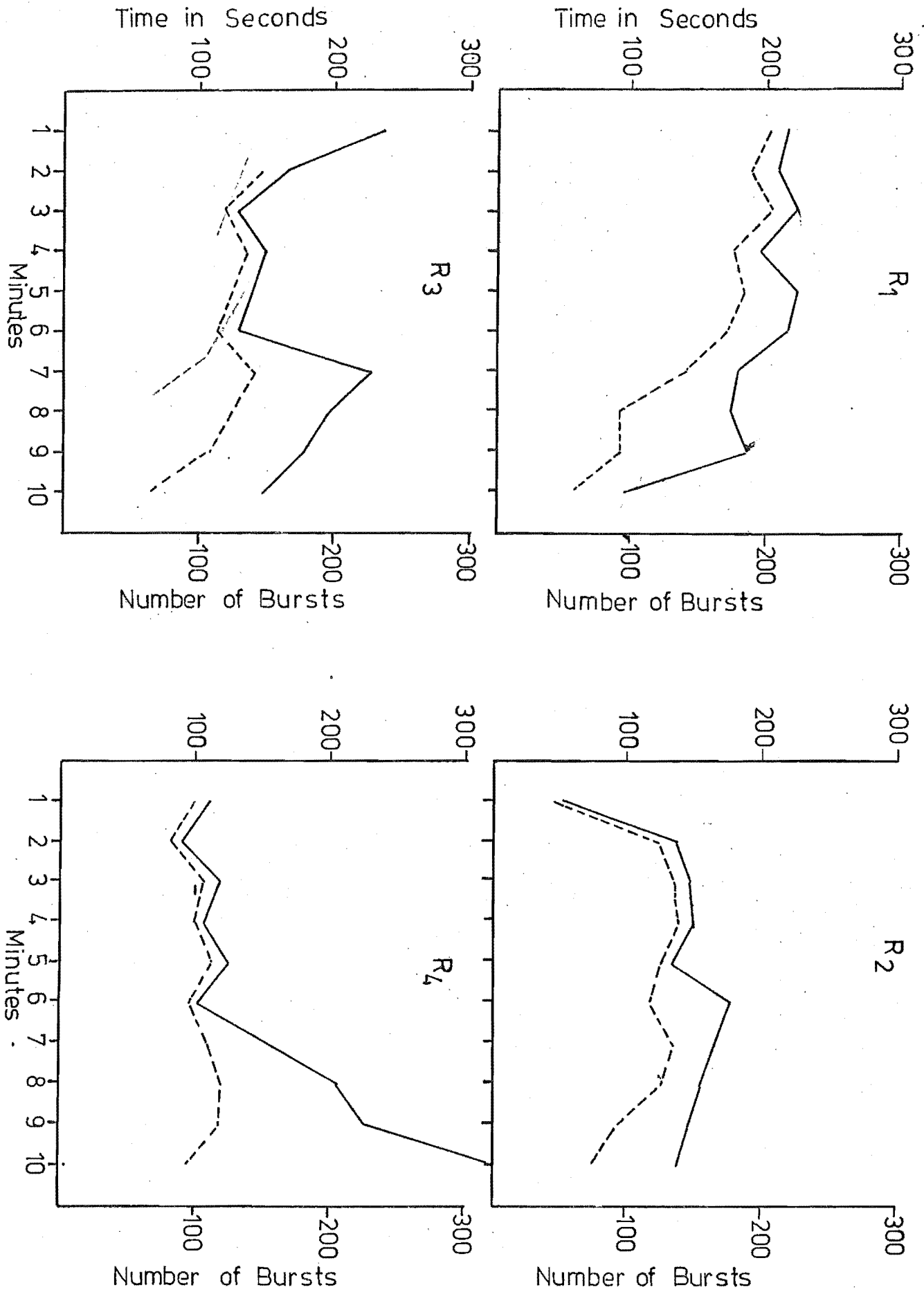


FIGURE 3: DRINKING PERFORMANCE OF EACH RAT DURING EACH MINUTE OF THE EXPERIMENTAL SESSION.

— Total time spent drinking  
 - - - Total number of bursts



FIGURE 4: RANK SUCCESS EACH MINUTE : TIME SPENT DRINKING

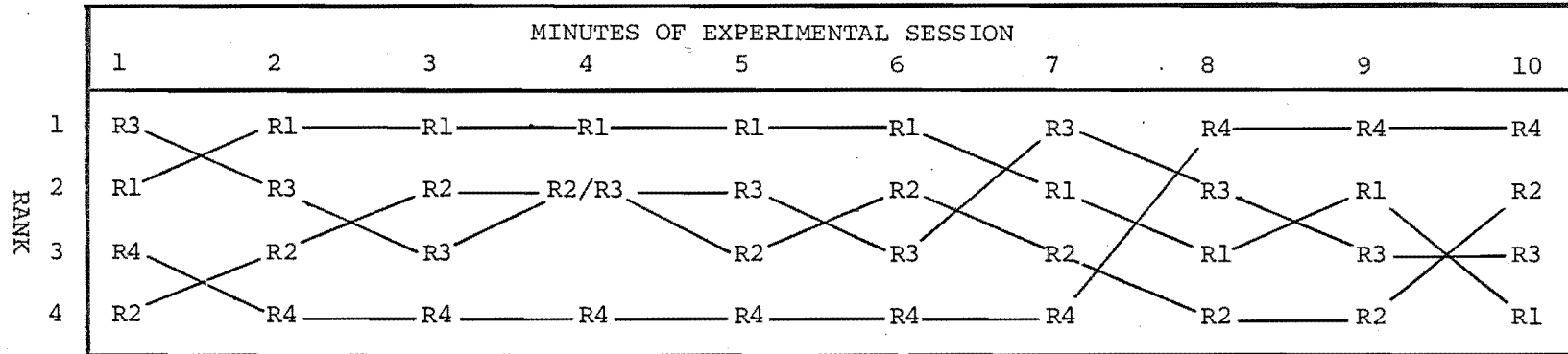
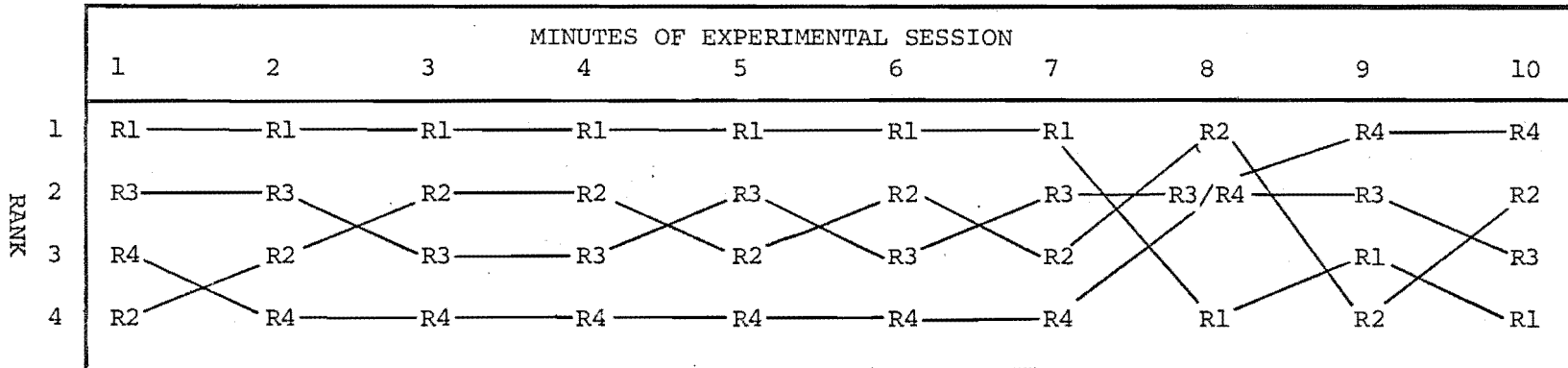


FIGURE 5: RANK SUCCESS EACH MINUTE : NUMBER OF DRINKING BURSTS



## CHAPTER FIVE

### THE PECK ORDER AND PRIORITY FOR FOOD

Since inquiry into social dominance can be traced to observations of the domestic fowl (Schjelderup-Ebbe, 1922) dominance studies on this species are of particular significance. They have probably influenced the understanding of dominance more than studies on any other species, although primates are perhaps now the most popular subjects for research. The studies reported below examine the competitive behaviour of the domestic fowl. They were conducted at Ruakura Agricultural Research Station where two groups of roosters were made available.

The final study of the previous chapter was aimed at exploring the effects of departures from the paired-comparisons paradigm, and at examining sequential ascendance within competition in a group context. In the experiments reported below one group of roosters was employed in the further examination of each of these problems. The experiments were conducted concurrently.

#### 5.1 EXPERIMENT 7

##### 5.1.1 INTRODUCTION

Candland, Matthews and Taylor (1968) have referred to the difficulty in obtaining aggressive orders by either group-observation or paired-comparison methods where the order is stable. They noted little aggression from domestic chickens which have been together for several weeks, and developed the

'wedge' technique for measuring success in paired-comparisons food-competition. The rank order thus obtained was reliable and perfectly correlated both with paired aggressive encounters, and full flock aggression. They say of their method, "Such a procedure should permit repeated determinations of the order despite the decrease in aggression in the flock, ensure that data are obtained for every possible pair of birds, and increase the efficiency of measuring dominance orders".

Insofar as the paired-comparisons method reflects the feeding behaviour of the whole group their findings are predictable from the traditional dominance viewpoint. Those birds ranking most highly on the peck order are considered to have priority to food and roosting sights and greatest freedom within the pen (Wood - Gush, 1971).

Syme and Syme (1974) found the correlation between peck order and performance in group competition was low and negative in two groups of roosters. While these authors employed a 10 second time-sampling procedure with subjects of a hybrid White Leghorn x Australorp strain, Candland et al (1968) measured the total time the food source was controlled by White Leghorn cockerels. These differences could have been responsible for their divergent results. However, it is also possible that the differences reflect differences between the paired-comparisons and group test situations. Accordingly, experiment 7 was designed to study the effects of increasing the number of group members in a competitive context in which the dependent variable remains unchanged.

The total time measure employed by Candland et al (1968) appeals as a more sensitive measure than time-sampling. However, mention is made in the previous chapter of the difficulty in measuring the performances of more than two

subjects. A third possible method employs a discrete reward situation, which from the experimenter's point of view shares the advantages of the time-sampling method without the loss of information. On the other hand, the natural occurrence of such competition may be rare, but for these studies this was the technique chosen.

#### 5.1.2 SUBJECTS

The subjects were 7 roosters (White Leghorn x Australorp) aged about 15 months at the beginning of the experiment. Since age 3 weeks the subjects had been housed together in an interior compartment (1.2 x 1.2 x 1m) connected by a guillotine door to an outdoor pen constructed of chicken mesh and measuring 2.3 x 1.6 x 1.2m high.

#### 5.1.3 METHOD

Prior to daily feeding, testing was carried out in the outdoor pen, with the guillotine doorway to inside roosting sights closed. The experiment was conducted only in fine weather. Birds not being tested were moved to a pen immediately adjacent to the home pen. The subjects were initially tested alone with small pieces of meat being individually presented on a 30cm rod through a hole in the chicken mesh. Each bird was presented with 40 such pieces which were consumed in a single session. Paired-comparisons competition followed on succeeding days. Each bird was randomly paired with each other bird and 5 pieces of meat were presented in the manner described. Within a complete round-robin the greatest possible number of rewards was 30

for any bird. Thus, a complete round-robin could be conducted each day without satiation. After three such rounds the subjects were tested in groups of 3. For 7 birds there are 35 possible triads, each bird occurring 15 times. Triads competed for 8 pieces of meat and a complete round-robin was conducted over three days. After three complete rounds were three further rounds of paired-comparisons, and finally the entire group competed for 100 rewards for two consecutive days. In these two sessions a different group of roosters occupied the adjacent pen.

Throughout the period of experimentation the group was observed for 1 hour/day in a non-competitive context, with pecks between birds being recorded.

#### 5.1.4 RESULTS AND DISCUSSION

There are two possible ways of assessing competitive success. First, an order can be obtained by summing the total number of raw values over an entire round (Raw Score Analysis). Alternatively, the outcome of every possible pairing can be established and an order derived from the total number of wins (Win-Loss Analysis). The relative merits of these two procedures are discussed below, but both methods were employed in the present study.

##### 5.1.4A Peck Order

The two modes of analysis applied to the peck matrix give orders based on the total number of pecks delivered versus pecks received (Raw Score Analysis), or for each bird, the total number of birds 'dominated' - indicated by pecks delivered outnumbering pecks received (Win-Loss

Analysis). The orders thus obtained are shown in Tables 9 and 10. Of the two orders the win-loss order has the disadvantage of a three-way tie. However, two points favour the use of the win-loss method:

- (i) Although not clearly stated anywhere, the traditional view of dominance implies this approach, and it is the method generally used.
- (ii) The behaviour observed in this and a previous study gives support to the order obtained under the win-loss analysis.

(i) A quote from Guhl (1969) is representative of those in which the win-loss mode of analysis is implied. "The hierarchies (Allee, 1952) may be based on unidimensional depotism, a 'peck-right' system, in which the individuals are ranked according to the number of individuals in the group that each may dominate without retaliation. The order may be straightline or have a geometrical pattern consisting of "pecking triangles". Some species, e.g., pigeons and doves, show bidirectional dominance (formerly designated as "peck-dominance") in which individuals exchange "pecks" but one of each contact pair maintains an advantage by means of a higher frequency of attacks (Bennett, 1939). This social order is less stable than the "peck-right" system."

The peck-right or unidirectional peck order which has been reported in the literature, and which is now assumed to be typical of stable groups of domestic fowl (King, 1965) was not observed in the present study. This is seen from Table 9.

- (ii) Observed behaviour adds support to this approach. S1, ranked first on this measure was described as top of the peck

order in a study on the same group by Syme and Syme (1974) on reactions to threat. The behaviour of S1 reported by Syme is similar to that of the dominant rhesus macaque described by Bernstein (1964). On 15 out of 20 occasions this bird was the first to emerge from hiding after the group had been threatened.

The behaviour observed in the present study gave further support to the win-loss analysis. S3 was ranked first on the raw-score hierarchy. This subject did exhibit behaviour more closely approaching despotism - a high frequency of pecks were delivered while few were received, the subject spending a good deal of time stalking and pecking other members of the group. At the same time this bird clearly gave wide berth to S1, choosing the opposite side of the pen whenever possible. Though seldom missing an opportunity to peck the other members of the group. S3 was never observed pecking S1. There were 12 pecks observed in the opposite direction. This unidirectional relationship was observed in only 3 of the 21 dyads.

While the win-loss analysis may be favoured on these counts, yet shortcomings remain in both indices. In the present study behaviour bearing some resemblance to alliance formation was observed. When one bird was pecked by another, other birds frequently continued the attack, adding their own pecks to those of the original aggressor. The avoidance behaviour of the attacked bird, with neck extended and head close to the ground, made it a vulnerable target. The behaviour differed from the alliance formation in macaques described by Varley and Symmes (1966) insofar as the co-action did not appear to depend upon which birds were involved in

the original interaction. The behaviour rather than the identity of the pair appeared to determine its onset. It was apparent that this sort of co-action was more typical of some members of the group than others (especially S5), and hence distorts both rank orders. If this co-action occurs in groups of birds generally, then the observation of Wood-Gush (1971) that "birds low on the scales generally attack their inferiors more than do birds higher up" would mean a bias in the peck order toward authoritarianism. However, in view of the reports of unidirectional dominance it appears that both this behaviour and the bidirectional pecking referred to above are atypical of the domestic fowl, and maybe specific to the particular strain used, or to the housing conditions.

Nevertheless, the peck-order is of doubtful validity as an indicator of group social structure, but a clear definition of 'dominance' is required before a fair assessment can be made either of the peck order as an indicator of dominance status, or of the importance of dominance in the social life of the group.

#### 5.1.4B Dominance: The Mathematical Approach

Van Kreveld's (1970) definition of dominance was the "priority of access to an approach situation or away from an avoidance situation that one animal has over another". Bartos (1967) adds three distinguishing characteristics of dominance relationships - they are antireflexive, nontransitive and antisymmetric, i.e.

- (i) a subject cannot dominate himself;
- (ii) it is possible that A dominates B, B dominates C, but that C dominates A;



(iii) one subject cannot both dominate and be dominated by another.

Both Van Kreveld and Bartos are writing about dominance relationships, where most experimental work has centred on dominance patterns or structures, usually hierarchies derived from data treated ordinally. Thus dominance hierarchies are assumed once data hierarchies have been demonstrated. In the derivation of dominance patterns there is a presupposition that dominance relationships exist between every possible pair within the group. This is Bartos' third condition.

His second condition is generally held by writers in this area along with belief in unidimensionality. Syme (1974) has discussed this widespread assumption that dominance is unidimensional. But transitivity is a necessary condition for a one-dimensional attribute to mediate any behaviour (Coombs, Dawes and Tversky, 1970). In the experimental literature intransitivity has not been seen to preclude unidimensionality. For example, the quote from Guhl (1969) cited above refers both to unidimensionality and to pecking-triangles. This may hinge on two uses of the term 'unidimensional'. In Coombs, Dawes and Traversky's use of 'unidimensional', a given priority is mediated by a single attribute. This does not imply generality. Baenninger (1970) uses the term in a different sense - possibly, whatever attribute(s) mediate(s) one priority similarly mediate(s) all other priorities. Hence, generality is implied and pecking triangles are possible if they are reflected in other priorities.

Kemeny, Snell and Thompson (1956) use different terminology but they give two conditions for a dominance

relation which correspond to Bartos' antireflexive, and anti-symmetric conditions. They add as an after-thought, "A moment's reflection shows that the transitive law need not hold for dominance relations".

Obviously these writers are concerned with the mathematics of behaviour rather than any social mechanism. In the absence of a clear demonstration of any underlying process, the mathematical approach may be the more valid, and solves the otherwise enigmatic problem of definition.

#### Power and Authority

Having obtained a set of dominance relations in this sense, a distinction can be drawn between authority and power. Homans (1961) writes of authority, "the larger the number of other members a single member is regularly able to influence, the higher is his authority in the group". Kemeny, Snell and Thompson (1957) refer to the "power" of an individual which they define as "the total number of one-stage and two-stage dominances which he can exert". Power, according to Bartos (1967), refers to the more complicated relationship between individual and group. Power appeals as an index of social status in that an individual's inferred position depends upon the particular individuals he dominates.

Unfortunately, data from the win-loss analysis of Experiment 7 do not meet Bartos' (1967) criteria since ties have been observed. This is not surprising where there is bidirectional pecking, and Bennett (1939), for example, reports a number of even scores at the times of summarizing peck-orders in flocks of ringtail doves. Nonetheless, the number of wins by each bird approximates an authority vector, and the rank order thus obtained an authority hierarchy.

Slight adjustments were made to the pecking matrix obtained in the present experiment to meet Bartos' criteria and the authority and power vectors derived. The ties in the matrix obtained were between S1 and S5, and S2 and S5 respectively. The behaviour of all three has been described in some detail. It seems reasonable to assume the coactive pecking of S5 elevated this subject's position relative to both other birds. This assumption is made, and the following dominance matrix thus obtained.

$D_{ij} = 1$  implies  $S_i$  is dominate over  $S_j$

	S1	S2	S3	S4	S5	S6	S7
S1	0	1	1	1	1	1	1
S2	0	0	0	0	0	1	1
S3	0	1	0	1	1	1	1
S4	0	1	0	0	0	1	0
S5	0	1	0	1	0	1	1
S6	0	0	0	0	0	0	0
S7	0	0	0	1	0	1	0

Summing across rows an authority vector is obtained.

Authority Vector	Rank
6	1
2	5
5	2
2	5
4	3
0	7
2	5

In ranking, S3 has been elevated to second position below S2, but above S5. The hierarchy otherwise remains the same as the win-loss order.

Squaring the dominance matrix.

	S1	S2	S3	S4	S5	S6	S7
S1	0	3	0	3	1	5	3
S2	0	0	0	1	0	1	0
S3	0	2	0	2	0	4	2
S4	0	0	0	0	0	1	1
S5	0	1	0	1	0	3	1
S6	0	0	0	0	0	0	0
S7	0	1	0	0	0	1	0

By adding  $D$  and  $D^2$ , a matrix,  $S$ , is obtained representing the sum of first and second order dominances.

$$S = D + D^2$$

	S1	S2	S3	S4	S5	S6	S7
S1	0	4	1	4	2	6	4
S2	0	0	0	1	0	2	1
S3	0	3	0	3	1	5	3
S4	0	1	0	0	0	2	1
S5	0	2	0	2	0	4	2
S6	0	0	0	0	0	0	0
S7	0	1	0	1	0	2	0

The resultant power vector is obtained by summing the rows.

Power Vector	Rank
21	1
4	5
15	2
4	5
10	3
0	7
4	5

In this case the power hierarchy remains the same as the authority hierarchy.

The appeal of the power vector as an index to group status comes from the differential weighting of a success. Position is elevated more by the defeat of a 'successful' competitor than by the defeat of an 'unsuccessful' competitor.

In order to compare the findings of the present study with those in the literature, the "peck-order" refers to the hierarchy derived in the traditional (win-loss) manner. The mathematical approach does have obvious advantages over the traditional approach.

- (i) It avoids the problems surrounding definition and provides clear criteria for dominance relations to be identified.
- (ii) It clarifies the difference between dominance relations and dominance structures.
- (iii) It resolves the problems surrounding unidimensionality.
- (iv) It opens the door to the use of power vectors which may prove to be better indices of group status than are the pecking or competition hierarchies generally obtained.

Yet despite these advantages and the possible usefulness of a mathematical approach, it represents a side-stepping of the problems of social dominance rather than a solution to them. The very term "dominance" acquires a different, more restricted meaning, and possibly becomes redundant. We begin and end with a single behavioural category. (Although the rejection of the presupposition of unidimensionality does not preclude the discovery of it.) The retention of the

term "dominance" should be made contingent upon the discovery of concordant priorities involving a variety of behavioural responses, and in the absence of a demonstration of such concordance it seems preferable to avoid the concept of dominance altogether.

The aim at this point is to defend the concept if possible, and the mathematical approach is thus inappropriate.

#### 5.1.4C Competitive Testing

In assessing the reliability of competitive scores both the win-loss and the raw score modes of analysis have been employed in the literature (Syme, 1974). As indicated above, data from the present study have been analysed both ways.

##### Raw Score Analysis:

Kendall coefficients of concordance were calculated for the two blocks of paired-comparisons and the three days of triad-testing. A Spearman rank correlation coefficient was calculated for the two days of group competition. These values are presented in Table 11. Only the orders for group competition were reliable ( $\rho = 0.71$ ,  $p < 0.05$ ).

##### Win-Loss Analysis:

Kendall coefficients of concordance and a Spearman correlation coefficient were calculated in a manner parallel to that of the raw score analysis. The results are summarized in Table 12. For whole group competition the distinction between raw score and win-loss analyses disappears.

Comparing Tables 11 and 12 the reliability of the orders from the win-loss analysis appears to be more significant. However, the values for W show little difference.

The orders that were reliable at the 0.05 level were correlated with the peck order. The results, which are presented in Table 13, are interesting. The correlation between competitive orders and the peck order increases with the size of the competitive group. Thus the order for pairs competition is in least agreement with the peck order ( $\rho = -0.64$ ,  $p > 0.05$ ) while the order for group competition is in greatest agreement ( $\rho = 0.81$ ,  $p < 0.05$ ).

Zajonc (1965) has formulated a theory based on the Spence-Hull theory, whereby the presence of conspecifics, either as an audience or as co-actors, increases the probability of the dominant response, and decreases the probability of competing responses. This study suggests the response hierarchies and not merely the response probabilities within a given hierarchy may be dependent upon the behaviour and identity of the conspecifics. No firm conclusion can be drawn.

If group and paired competitive orders are different, this is of some significance to dominance theory in that the great majority of studies in this area employ the paired-comparisons approach. The differences between orders obtained from different competitive tests may disappear if group rather than paired testing is used. However, Syme and Syme's (1974) finding that group competition and the peck order had low and negative correlation suggests neither method will demonstrate the generality of priorities described by dominance theorists, and least in the domestic fowl.

## 5.2 EXPERIMENT 8

### 5.2.1 INTRODUCTION

The second experiment was designed along similar lines to Experiment 6 from the preceding chapter. Competition was observed in the group context and again attention was given both to events within competition and to overall competitive success. The peck order was compared with various aspects of competitive performance.

Ambiguity in the precise meaning of 'priority' clouds many statements relating to dominance generally, and the peck order particularly. Van Kreveld (1970) defines dominance as "a priority of access to an approach situation or away from an avoidance situation...". Wood-Gush (1971) states, "since the peck-order forms the basis of all social behaviour in chickens its effect on the individual has been reported by several workers... High ranking birds which deliver most threats and win most fights also have priority for food, nests, roosting places, and greater freedom of the pen."

In both these statements there is ambiguity in the word "priority". For example, it could be that a bird with such priority would be first to eat in a competitive situation. While this would seem closest to the literal meaning of "priority", the previous chapter showed that the initial stages of competition, at least in the rat, may be characterised by the greatest amount of disorder. Alternatively, priority may be inferred from the overall consumption in a competitive context. The dependence of success upon the length of competition has been discussed previously, and



Syme, Pollard, Syme and Reid (1974) stress the importance of ensuring a truly competitive period in this type of study. Even so, it is difficult to see how priority can be inferred from overall consumption without assuming purposiveness, unless it is stipulatively defined as such.

Beyond these possibilities there are at least two other possible indications of priority. A bird with priority might displace any other at the food source whereas lower ranking birds displace only those of roughly equivalent or lower rank. Thus, examination of the sequence of 'successes' independent of the total amount consumed could indicate relative priorities. Finally, priority may be reflected in the degree of unbroken control birds maintain at the food source. In the case of discrete rewards, this would be reflected in the proportion of successes which are consecutive.

Summarising, the possible indices of priority are:

- (i) First successes.
- (ii) Amount consumed over the entire observational period.
- (iii) Control transitions at the food source.
- (iv) Consecutive successes.

These possibilities are investigated in the present experiment, each measure being compared with the peck order.

#### 5.2.2 SUBJECTS

The subjects were 8 roosters (White Leghorn x Australorp) aged and housed in a manner similar to those of the previous experiment.

#### 5.2.3 METHOD

As in the preceding experiment a discrete reward

competitive context was chosen. The advantage of this method is the relative ease of recording the performances of a whole group of competitors. The data are easily manageable, permitting analysis both sequentially and in terms of total consumption.

Prior to daily feeding the guillotine door between the exterior pen and the interior roosting sights were closed. Testing was carried out on fine days in the exterior pen, with small pieces of meat being presented every 10 seconds in a manner similar to that of Experiment 7. 350 such rewards were presented each day for 7 days. Over this competitive period a record was kept of pecking behaviour, and a peck matrix was derived.

#### 5.2.4 RESULTS

A total of 195 pecks were observed representing interactions between all possible pairs. Once again the pecking was bidirectional and two ties were obtained. A peck order was obtained in the usual manner and is presented in Table 18, along with rank orders derived from the four measures of competitive success. Measures of the possible indices of priority were treated as follows:

##### 5.2.4A First Success

Birds were ranked according to the order of their first success (food consumed) for each session. These ranks are presented in Table 14. The Kendall coefficient of concordance was significant over these 7 days ( $W = 0.47$ ,  $p < 0.01$ ). From the mean of the 7 ranks an overall rank was assigned to each bird. A Spearman correlation between this

rank and the peck-order was non-significant ( $\rho = 0.52$ ,  $p > 0.05$ ).

#### 5.2.4B Overall Success

Overall success for each session is represented in Table 15. These orders are based on the number of "successes" (pieces of meat consumed) each day. A Kendall coefficient of concordance indicated the competitive orders over the 7 days testing were reliable ( $W = 0.59$ ,  $p < 0.001$ ). A Spearman correlation was calculated between the overall rank and the peck-order. The resultant value ( $\rho = 0.70$ ) was significant at the 0.05 level confirming the finding for group competition in Experiment 7.

#### 5.2.4C Transitions

Table 16 represents a summary of all the transitions throughout the entire experiment. For a given cell the row indicates the preceding bird, while the column indicates the next bird in the sequence. Corresponding row and column totals are not required to be equal insofar as birds at the beginning of each session preceded without following. Similarly, at the end of each session birds followed but did not precede any other.

From this table a transition matrix, A, was obtained:

Transition Matrix

	S1	S2	S3	S4	S5	S6	S7	S8
S1	.45	.13	.03	.03	.11	.06	.05	.14
S2	.19	.43	.02	.05	.12	.02	.04	.13
S3	.26	.03	.33	.00	.05	.06	.04	.24
S4	.29	.12	.04	.25	.11	.07	.04	.09
S5	.15	.07	.02	.01	.58	.03	.04	.08
S6	.19	.12	.03	.04	.12	.28	.06	.15
S7	.21	.10	.03	.04	.13	.04	.40	.06
S8	.21	.09	.05	.01	.07	.08	.02	.46

$A_{ij} = p(S_i \rightarrow S_j)$  the probability that  $S_i$  is followed by  $S_j$

The important transitions are those between one state and a different state. In other words the leading diagonal is not important at this stage. However, the entries in this diagonal clearly give the highest probabilities in almost all cases, i.e. given one success the birds had a high probability of gaining a consecutive success.

In order to examine between subject transitions a new transition matrix, B, of conditional probabilities was derived.

$B_{ij} = p(S_i \rightarrow S_j / S_i \text{ does not follow itself})$

Since only between subject transitions are represented the entries in the leading diagonal must all be zero, while the sum of row elements, allowing for rounding, remains one. Although the relative frequencies of success vary widely between subjects the expected probabilities must be equal and are thus 0.14 for every cell (other than the leading diagonal).

	S1	S2	S3	S4	S5	S6	S7	S8
S1	0	.24	.06	.06	.20	.11	.09	.26
S2	.33	0	.04	.09	.21	.04	.07	.23
S3	.39	.05	0	.00	.08	.09	.06	.36
S4	.39	.16	.06	0	.15	.10	.06	.12
S5	.36	.17	.05	.03	0	.08	.10	.19
S6	.27	.17	.05	.06	.17	0	.09	.21
S7	.35	.17	.05	.07	.22	.07	0	.10
S8	.39	.17	.09	.02	.12	.14	.04	0

Expected and obtained frequencies corresponding to the

probabilities presented in each row were compared using a series of  $\chi^2$  tests. The results presented in Table 17 show that all values of  $\chi^2$  are significant ( $p < 0.001$ ). An examination of Table 16 shows that the  $S_i \rightarrow S_1$  transitions occurred with the greatest frequency for all values of  $i$ . This is reflected in the high probabilities shown in the  $S_1$  column of matrix B above. Other probabilities which exceed the expected probability of 0.14 all fall into cells representing the  $S_i \rightarrow S_2$ ,  $S_i \rightarrow S_5$ , or  $S_i \rightarrow S_8$  transitions. Thus,  $S_1$ ,  $S_2$ ,  $S_5$  and  $S_8$  emerge as the most successful birds on this measure.

The behaviour of these four birds was quite distinctive.  $S_2$ ,  $S_5$  and  $S_8$  were observed to be almost constantly together, and when one of the three was eating the other two were close by. The alliance formation described by Varley and Symmes (1966) related to aggression and for this reason it is difficult to make comparisons with the behaviour observed here. However, these three birds could more aptly be treated as a single subject if comparison were to be made with the peck order. The resulting reduction of the sample size to five precludes testing for correlation with the peck order.

The fourth bird,  $S_1$ , appeared to eat quite independently of the other members of the group.

If the subjects are treated independently each bird can be assigned a rank on the basis of the probabilities in each row of matrix B. In this way each bird receives seven rankings from which overall ranks can be derived. The order presented in Table 18 was derived in this manner. The correlation with the peck order is non significant ( $r = 0.62$ ,  $p > 0.05$ ).

#### 5.2.4D Consecutive Successes

The leading diagonal of transition matrix A indicates the proportion of successes which were consecutive for each subject. Subjects were ranked according to these proportions and a Spearman correlation coefficient was calculated between this order and the peck-order. The correlation was non-significant ( $\rho = 0.53$ ,  $p > 0.05$ ).

#### 5.2.5 DISCUSSION

Of the indices of priority only overall competitive success correlated significantly with the peck order ( $\rho = 0.70$ ,  $p < 0.05$ ). This is surprising in that no precaution was taken to ensure a truly competitive period as recommended by Syme, Pollard, Syme and Reid (1974). In this study the decision to make 350 presentations was purely arbitrary and no control was made for motivation. The final condition of Experiment 7 was similar to the present study but differed at this point: 100 rewards were presented rather than 350. A comparison between these two studies is thus interesting.

The first success index proved unreliable for experiment 7 ( $\rho = 0.49$ ). For Experiment 8 the Spearman correlation was 0.52 between this measure and the peck order. The correlation between consecutive successes and the peck order was 0.52 for Experiment 7, and 0.53 for Experiment 8. The small number of presentations in Experiment 7 gave rise to low expected frequencies which precluded comparisons between expected and observed between-subject transitions. For both studies the overall success was the only measure to correlate significantly with the peck order. The Spearman correlations

were 0.81 and 0.70 for Experiments 7 and 8 respectively.

The agreement between the two studies suggests that the number of presentations may not have determined the degree of correlation between the competitive and peck-orders. Nevertheless this possibility was investigated.

For Experiment 8 competitive success after 100, 200 and 300 reward presentations was calculated from the cumulative number of successes for each animal each day. The Kendall coefficients of concordance and the correlations between these orders and the peck-order are presented in Table 19. The corresponding values for overall competitive success (350 presentations) are also presented. The values of  $W$  vary between 0.57 at 100 presentations to 0.65 at 300 presentations. This range is small. All values are statistically significant ( $p < 0.001$ ) showing reliability in the orders at each stage of competition. There is similarly little variation in the Spearman correlations which range from 0.65 at 200 presentations to 0.72 at 100 presentations. Orders at each stage of competition correlate significantly with the peck-order ( $p < 0.05$ ).

It is apparent that even at 100 presentations the correlation between competitive success and the peck-order does not reach the level of that observed in the previous experiment. This difference is discussed below, as is the consistency of correlations observed in the present experiment between the peck-order and competitive success at the different stages of competition. Motivational changes within each session might well have affected the latter.

Addressing the former problem first, there was an important difference between the two studies in the manner the

peck-order was derived. In the latter experiment the observations were of pecking behaviour in a competitive context. King (1965a) describes disruptions in the peck-order of cockerels concomitant with the degree of accessibility to food. Thus the order obtained in the present experiment may be misleading. Arguing against this, the number of ties was slightly greater in Experiment 7. King considers bidirectional pecking to be indicative of disruption: such pecking was typical of both groups. There was no obvious differences in the nature of the two pecking matrices, although the matrix for the latter study was made up of 195 pecks while the former was made up of 374. This difference alone may mean the previous peck-order more accurately described pecking relationships. Observations were made in the competitive context because of the long duration of each session in Experiment 8 (almost 1 hour).

While the methodological error in peck-order assessment in the present study and the relatively low number of pecks observed provide the most obvious explanation of differences between the two experiments, an alternative explanation is a difference in the nature of the two groups. Reference to pecking hierarchies, particularly where unidirectional pecking is observed, may mask important differences between groups. If unidimensionality is not presupposed, distances between adjacent members of the hierarchy as well as the overall pattern become especially important. A simple hierarchy was not observed in either of the experiments under discussion. Thus, one type of unidimensionality is precluded. Pecking was bidirectional thus leaving room for large differences between the groups while on paper the two pecking



orders appear equivalent. The peck-order may give some indication of the homogeneity of the group and as an authority vector has been used to calculate Landau's hierarchy index (Bartos, 1967), a measure of authority concentration. According to this measure the subjects from Experiment 7 provide a more homogeneous group. Three subjects share equivalent rank while only two subjects from Experiment 8 share equivalent rank. Observation of both groups lead to the opposite conclusion. The previously described behaviours of S1, S3 and S5, from Experiment 7, were quite distinctive. The general behaviour of subjects in the second experiment appeared more homogeneous. For example, no subject exhibited stalking and pecking behaviour to a degree approaching that shown by S3 in the previous study.

The over-simplifying effect of a rank order applies to competitive behaviour as well as to pecking. To illustrate this cumulative curves are presented (Figures 6 to 12) showing the success of the top three birds in overall competitive success. Figure 8 might be the expected pattern given the final competitive order, but it is clear from the other curves that it is the exception rather than the rule. It is also clear that relative competitive successes vary from day to day e.g. compare Figures 8 and 9 where there is no obvious ascendance. The variations in performance of S5 are also noteworthy.

The consistency of correlations between the peck-order and competitive success at each stage of competition was somewhat surprising. Changes were expected with changing motivation, however, birds may not have reached satiation within the sessions. Satiation should be reflected in plateaus in Figures 6 to 12 when the number of successes is

high. While there are some such plateaus (e.g. S8, Figure 7), there are similar plateaus when the number of successes is still low. In the absence of unequivocal evidence that satiation occurs within sessions the most parsimonious view is that birds are still somewhat deprived at the end of each session and hence the constant correlations obtained.

Accepting this view as the most tenable, there is another possible explanation. A low level of food-deprivation was used in these studies. Birds were tested prior to daily feeding and their daily ration was not reduced. Thus each experimental session provided food over and above the normal daily ration. Candland, Matthews and Taylor (1968) maintained subjects at 80% of their normal body weight, King (1965) used a 23 hour deprivation schedule and Syme and Syme (1974) used a 33 hour deprivation schedule. Thus the deprivation used here was comparatively low, and it is possible that factors other than food-deprivation motivated the competitive behaviour. Status within the group could be both asserted and maintained with the assertion of priority rights for food.

Since unidimensionality is not assumed, the generality of the findings of the present experiments is not known. They do indicate that in this type of food competition overall success is a measure closely related to the peck-order, but before Wood-Gush's (1971) statement can be accepted the relationship between the peck-order and other priority rights must be demonstrated. If such priorities are exhibited, then dominance in the traditional sense (Van Kreveld, 1970) does exist in the domestic fowl. In the meantime only situational dominance has been demonstrated, and the use of the term "dominance" in such a restricted sense is questionable.

Footnote:

At the conclusion of Experiment 8, Experiment 7 was still in progress. The distracting influence of non-competing group members in the adjacent pen had been noticed, and in view of the negative correlation between the paired-competitive order and the peck-order ( $\rho = -0.64$ ) it was postulated that the degree of distraction might be related to the position of the competing birds in the peck-order. Possibly high ranking birds would be more affected than lower ranking birds. A brief experiment was conducted on subjects from Experiment 8. Birds were tested individually in the home cage on four successive days. Five pieces of meat were individually presented to each subject while the remaining group members occupied the adjacent pen. Eating latencies were recorded. A Kendall coefficient of concordance showed the daily orders for mean latency to be unreliable ( $W = 0.46$ ,  $p > 0.05$ ). This is not surprising considering the uncontrolled behaviour of the adjacent birds.

In view of the explanation put forward in Experiment 7 further work on social distraction is warranted, particularly with regard to establishing whether the identities of the competing or non-competing animals are important.

TABLE 9

RAW SCORE ANALYSIS: Peck order derived from the ratio of the total number of pecks delivered to the total number received.

SUBJECT	DELIVERED	RECEIVED	RATIO	RANK
S1	68	31	2.19	3
S2	51	64	0.80	4
S3	68	19	3.58	1
S4	42	55	0.76	5
S5	80	33	2.42	2
S6	19	85	0.22	7
S7	46	87	0.53	6

TABLE 10

WIN-LOSS ANALYSIS: Peck order derived from the total number of birds 'dominated'.

SUBJECT	"WINS"	RANK
S1	5.5	1
S2	2	5
S3	4.5	3
S4	2	5
S5	5	2
S6	0	7
S7	2	5

TABLE 11RAW SCORE ANALYSIS: Reliability of competitive orders.

CONDITION	W	SIGNIFICANCE
P-C <sub>I</sub>	0.62	NS
TRIADS	0.62	NS
P-C <sub>II</sub>	0.58	NS
GROUP	$\rho = 0.71$	$p < 0.05$

TABLE 12WIN-LOSS ANALYSIS: Reliability of competitive orders.

CONDITION	W	SIGNIFICANCE
P-C <sub>I</sub>	0.67	$p < 0.05$
TRIADS	0.65	$p < 0.05$
P-C <sub>II</sub>	0.52	NS
GROUP	$\rho = 0.71$	$p < 0.05$

TABLE 13

Correlations between the reliable competitive orders under the win-loss analysis and the peck-order.

CONDITION	$\rho$	SIGNIFICANCE
P-C <sub>I</sub>	-0.64	NS
TRIADS	-0.19	NS
GROUP	0.81	$p < 0.05$

TABLE 14

Ranks obtained each session from the orders of first success.

SUBJECT	SESSION							OVERALL RANK
	1	2	3	4	5	6	7	
S1	2	1	1	4	3	1	2	1
S2	1	4	4	2	1	3	4	2
S3	6	8	5	6	7	6	1	6
S4	7	5	6	8	8	5	7	8
S5	5	7	8	3	2	2	5	4
S6	4	3	3	7	4	4	8	5
S7	8	6	7	5	6	7	6	7
S8	3	2	2	1	5	8	3	3

TABLE 15

Ranks obtained from the overall success of each competitor each session.

SUBJECT	SESSION							OVERALL RANK
	1	2	3	4	5	6	7	
1	1	2	1	2	3	1	3	1
2	3	7	2	4	4	2	4	4
3	7	5	5.5	8	8	8	5	7
4	8	8	8	7	6	4	7	8
5	6	1	7	1	1	3	2	3
6	4	6	5.5	5	5	6	8	6
7	5	3	4	6	7	7	6	5
8	2	4	3	3	2	5	1	2

TABLE 16

Total frequency of  $S_i \rightarrow S_j$  transitions in Experiment 8

	S1	S2	S3	S4	S5	S6	S7	S8	Total
S1	292	82	18	18	74	36	35	89	644
S2	69	158	7	17	43	9	14	47	364
S3	28	3	35	0	5	6	4	26	107
S4	22	9	3	19	8	5	3	7	76
S5	75	33	11	6	283	17	21	40	486
S6	30	19	4	6	19	44	10	23	155
S7	32	15	4	6	21	6	62	10	156
S8	94	43	24	5	34	35	8	212	456
Total	642	362	106	77	487	158	157	454	

TABLE 17

The results of  $\chi^2$  tests between the expected and observed frequencies for between subject transitions in Experiment 8.

TRANSITIONS	$\chi^2$ (df = 6)	SIGNIFICANCE
S1 $\rightarrow$ Sj	111.13	$p < 0.001$
S2 $\rightarrow$ Sj	114.7	$p < 0.001$
S3 $\rightarrow$ Sj	78.2	$p < 0.001$
S4 $\rightarrow$ Sj	31.71	$p < 0.001$
S5 $\rightarrow$ Sj	114.28	$p < 0.001$
S6 $\rightarrow$ Sj	34.13	$p < 0.001$
S7 $\rightarrow$ Sj	45.95	$p < 0.001$
S8 $\rightarrow$ Sj	151.73	$p < 0.001$

TABLE 18

Rank orders on the four measures of priority and the peck order (Experiment 8).

SUBJECT	FIRST SUCCESS	OVERALL SUCCESS	TRANSITIONS	CONSECUTIVE SUCCESES	PECK ORDER
S1	1	1	1	3	2
S2	2	4	3	4	7.5
S3	6	7	8	6	6
S4	8	8	7	8	7.5
S5	4	3	4	1	4
S6	5	6	5	7	3
S7	7	5	6	5	5
S8	3	2	2	2	1

TABLE 19

Reliabilities of orders (Kendall Coefficients of Concordance) and Spearman Correlations with the peck order of the overall success measure for each subject after 100, 200, 300 and 350 reward presentation.

NUMBER OF PRESENTATIONS	W	SIGNIFICANCE	$\rho$	SIGNIFICANCE
100	0.57	$p < 0.001$	0.72	$p < 0.05$
200	0.63	$p < 0.001$	0.65	$p < 0.05$
300	0.65	$p < 0.001$	0.70	$p < 0.05$
350	0.59	$p < 0.001$	0.70	$p < 0.05$



FIGURES 6-12: CUMULATIVE SUCCESSES DAILY FOR S<sub>1</sub>, S<sub>5</sub> AND S<sub>8</sub> (overall ranks 1, 3 and 2 respectively)

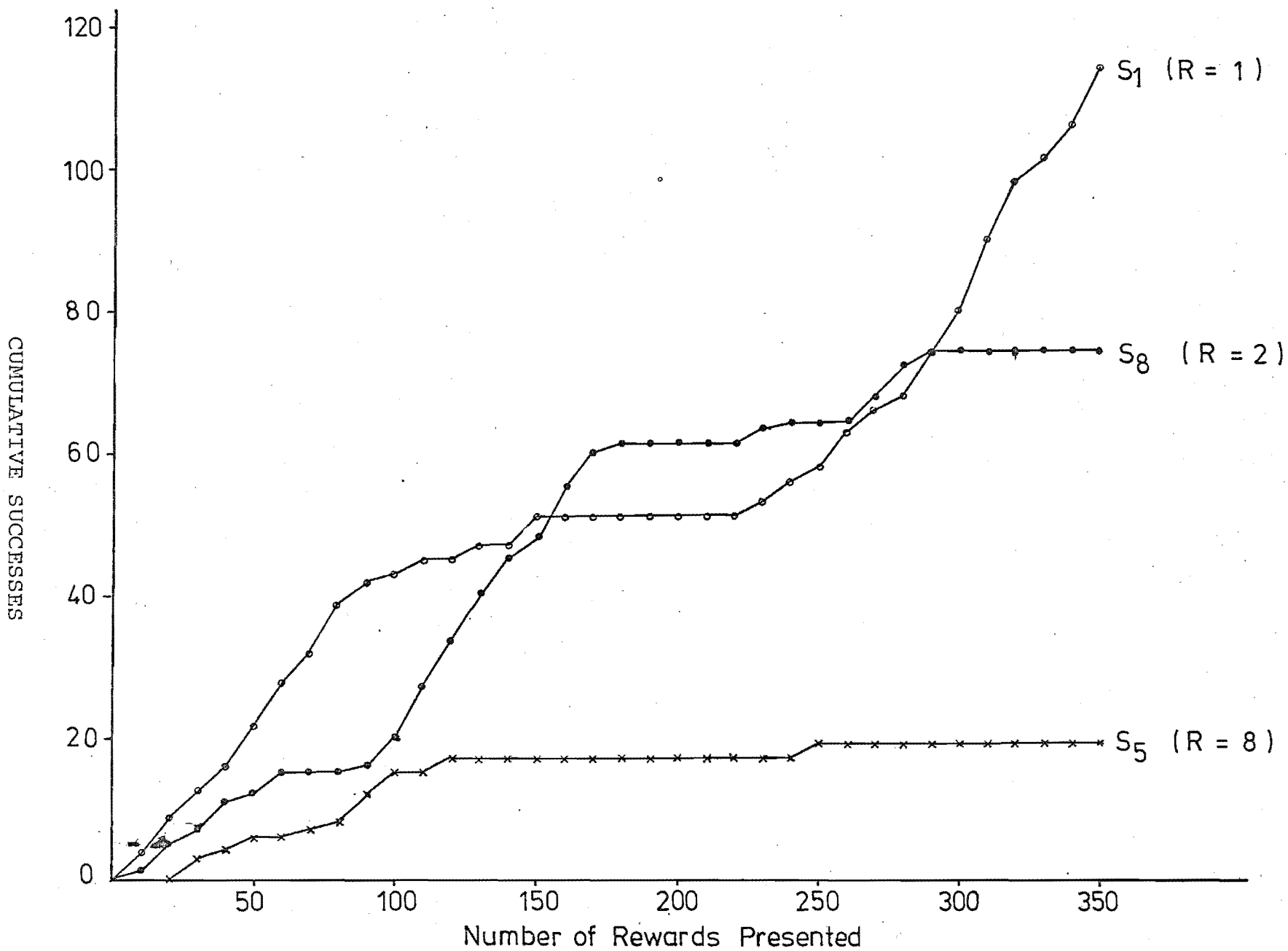


FIGURE 6: DAY 1

FIGURE 7: DAY 2

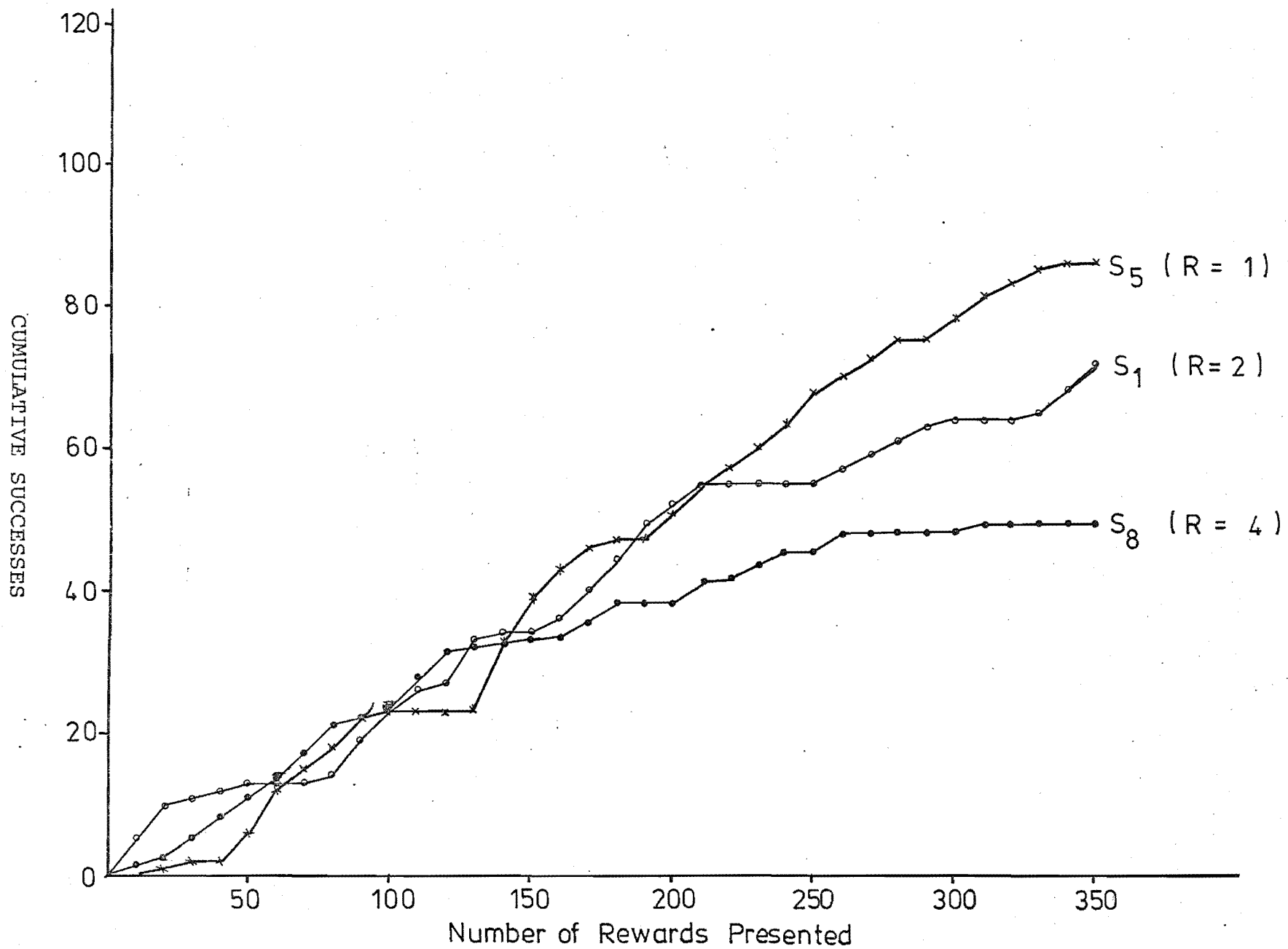


FIGURE 8: DAY 3

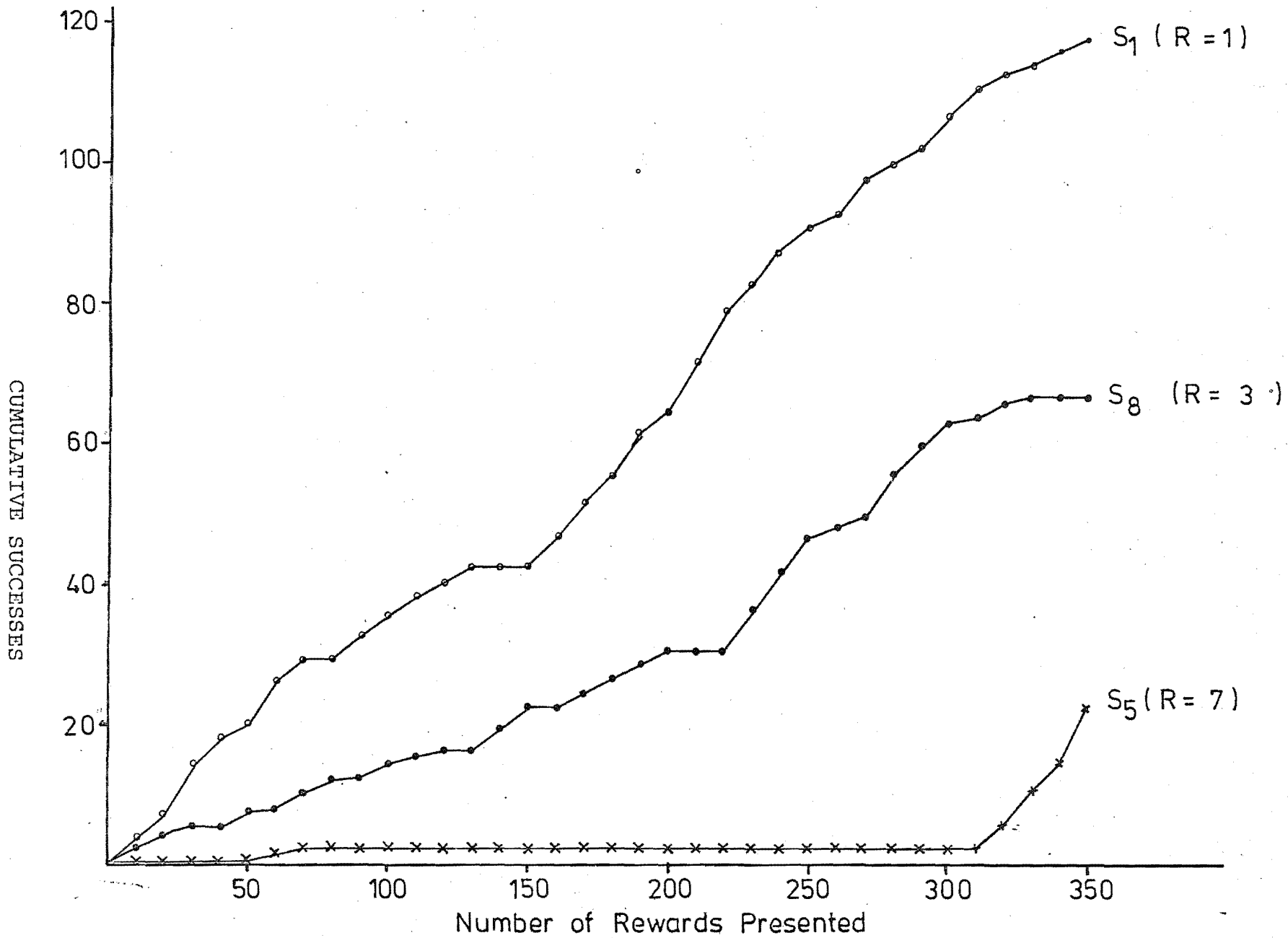


FIGURE 9: DAY 4

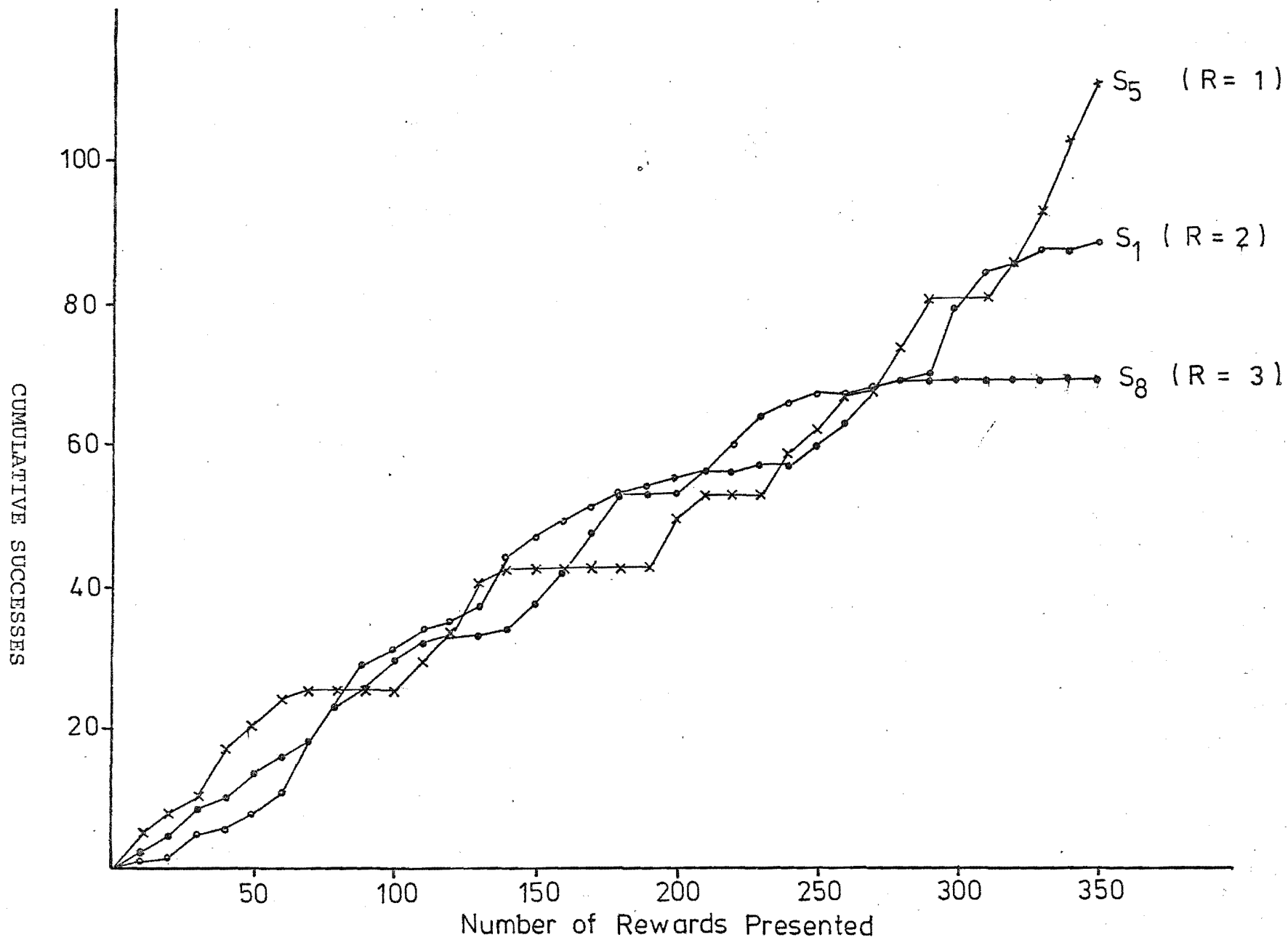


FIGURE 10: DAY 5

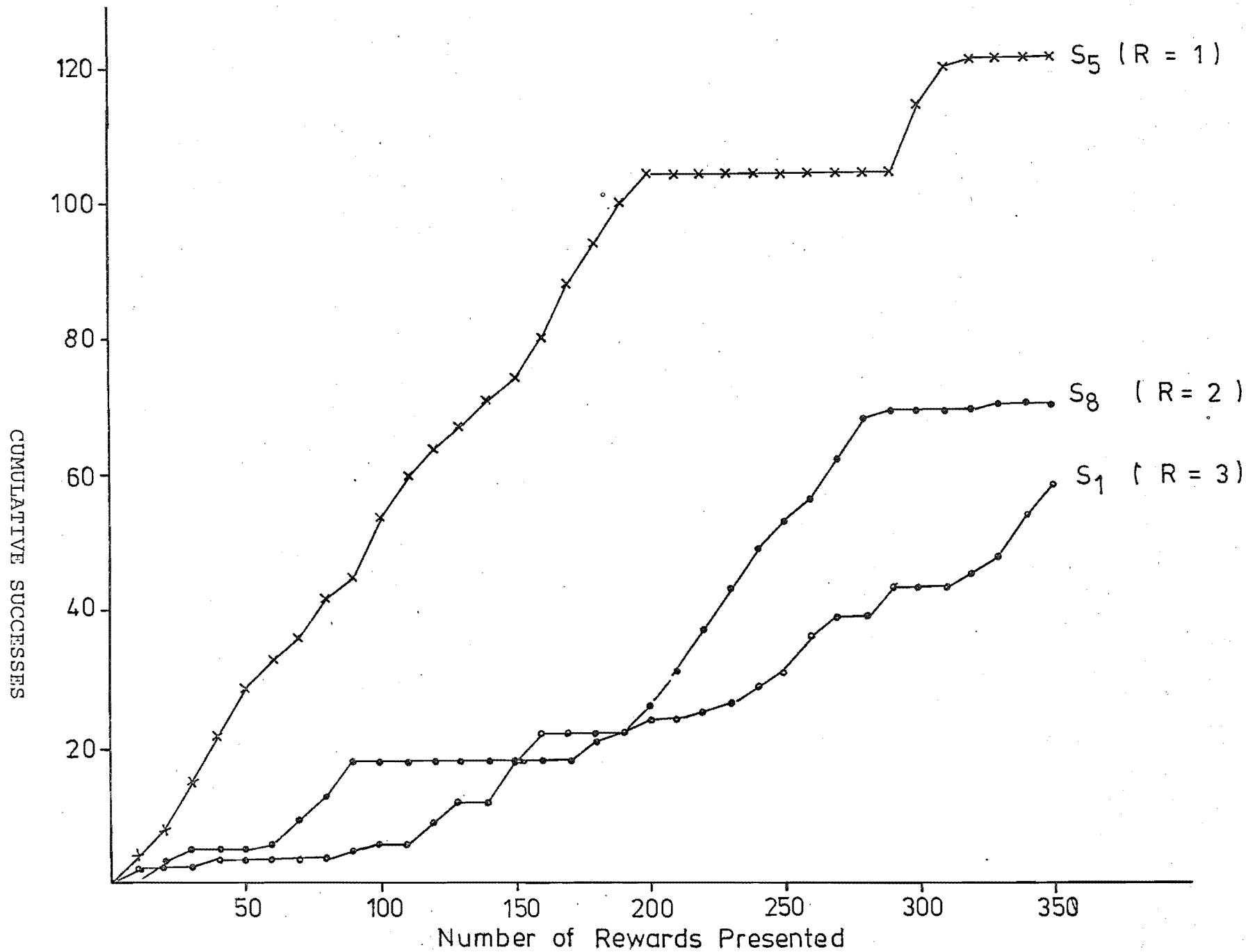


FIGURE 11: DAY 6

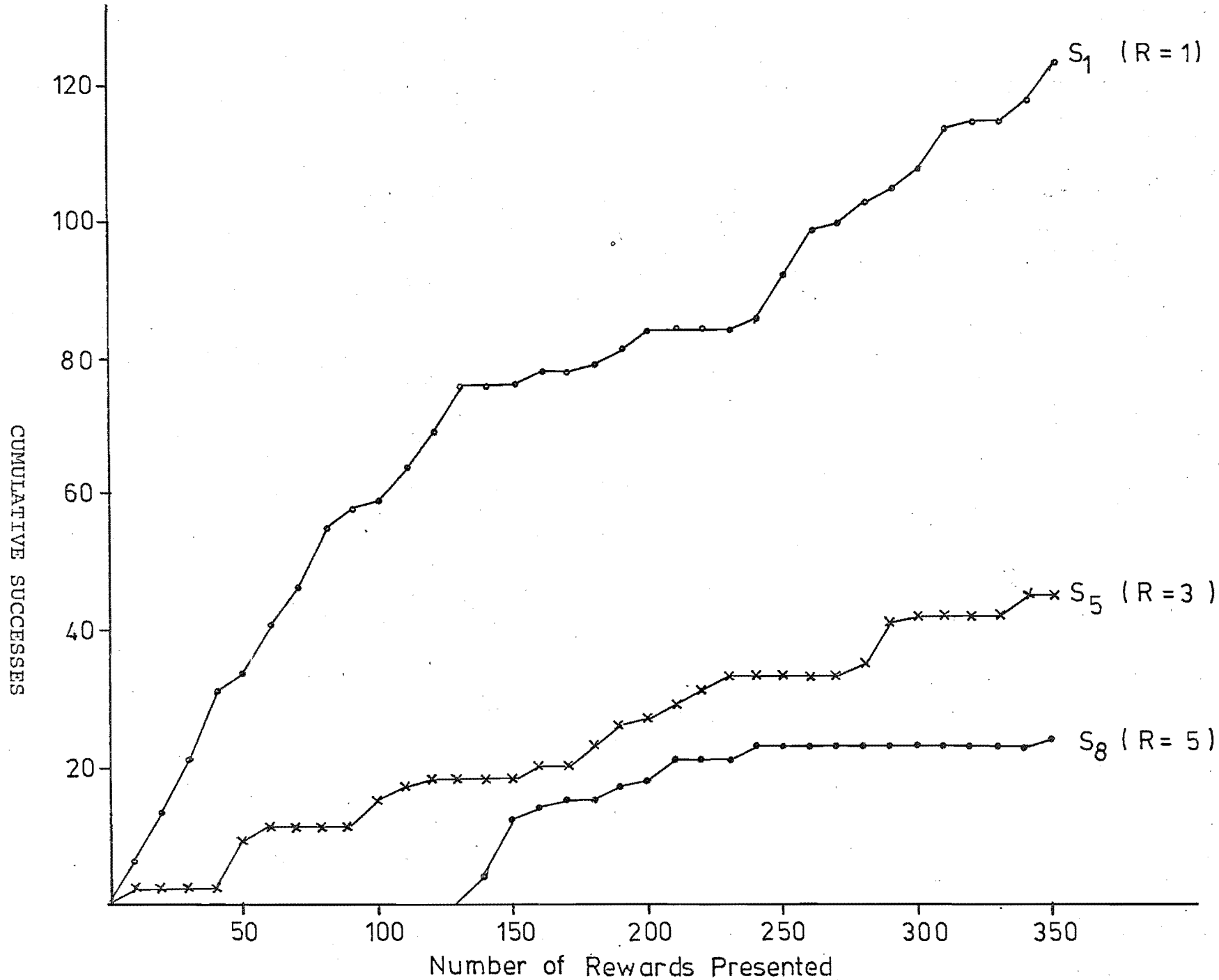
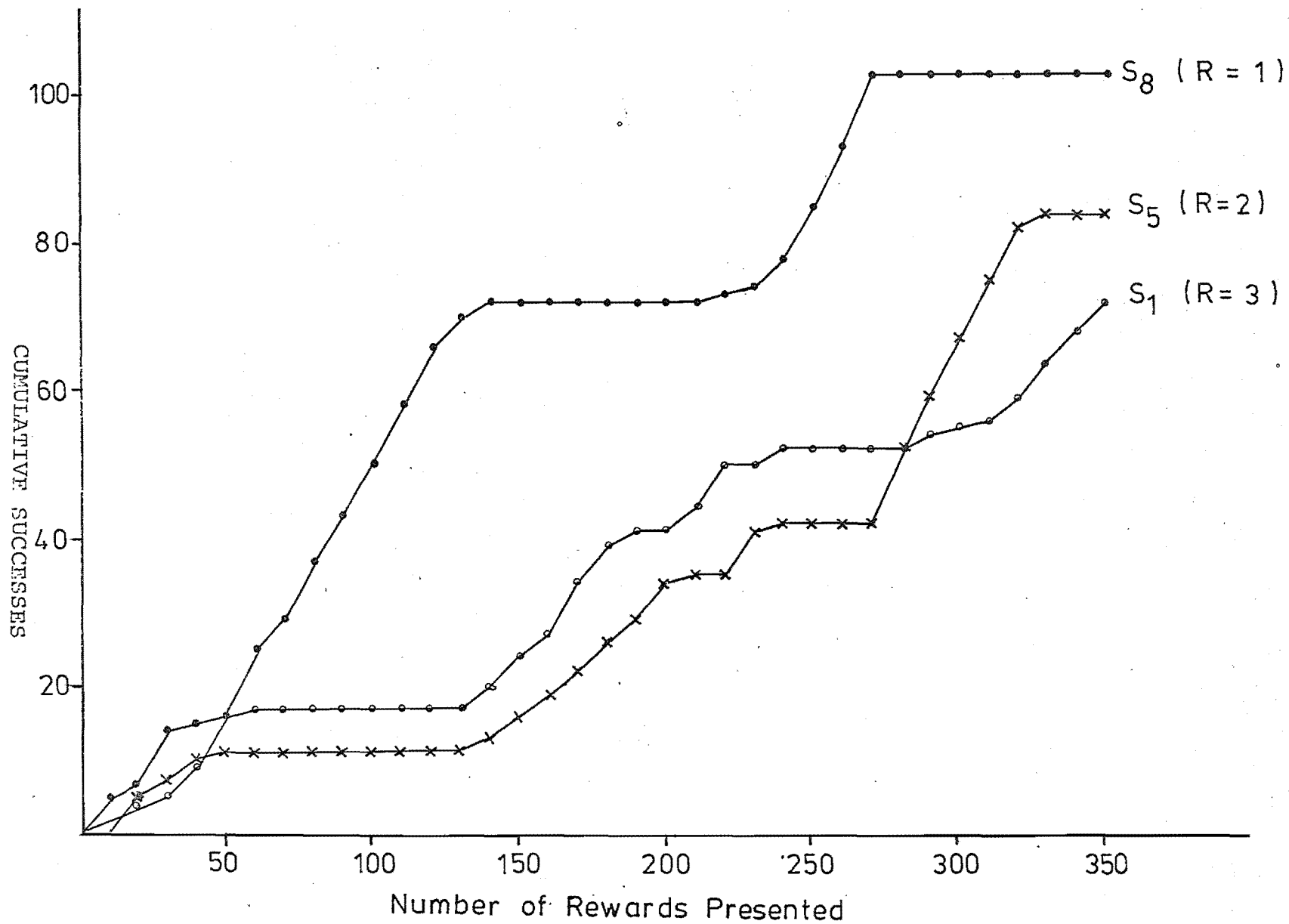


FIGURE 12: DAY 7



## CHAPTER SIX

PAIRED COMPARISON VERSUS GROUP COMPETITION

So far, arguments against unidimensionality have mainly arisen from the lack of agreement between aggressive orders and competitive orders, or the lack of agreement between various competitive orders. A characteristic of the great majority of studies reported in the literature is the use of paired-comparisons procedures. As suggested in the previous chapter, paired-comparisons may not give a good indication of performance in the group context. Since the concept of social dominance arose from observations in the group context (Schjelderup - Ebbe, 1922), the orders obtained in this context have the greater a priori validity. If these orders are different from those obtained in paired encounters, the lack of agreement between various competitive orders so far reported do not pose such a serious challenge to dominance theory. For the laboratory rat only Baenninger's (1970) findings appear to contradict the predictions of dominance theory. "Spontaneous", food and water orders were obtained in a group context and found to differ. However, there was no check on the internal validity of these measures (Syme, 1974), and there was agreement between the orders obtained in food and water competition.

In Chapter 5 a distinction was also drawn between four possible indices of priority which yielded different competitive orders for two groups of roosters. Of these measures, overall competitive success (measured by the total amount of food consumed in the competitive period) correlated



most highly with the peck order for both groups. In the literature overall competitive success measured by the amount consumed or time spent in consummatory behaviour is the index of priority used almost exclusively. It is possible that for species other than the domestic fowl another index more accurately reflects social status and shows a generality of priorities in various competitive contexts.

Thus the traditional understanding of dominance is still possible if either of two conditions holds:

- (i) If isolated paired encounters give a different indication of priority from encounters in a group context.
- (ii) If overall competitive success gives a different indication of priority from the other possible measures.

The present study was designed to test whether either of those conditions held for the laboratory rat. If not, insofar as the available indices of dominance have shown little generality of competitive orders, the traditional concept of dominance must be seriously challenged, at least in its application to the behaviour of laboratory rats.

## 6.1 EXPERIMENT 9

### 6.1.1 INTRODUCTION

The development of a discrete reward method in the previous chapter permitted relatively easy assessment of competitive success in the group context. Further, in using rewards of constant size the differences between weight and time measures disappear. An attempt was therefore made to develop a parallel procedure for rats. Since initial attempts were thwarted by animals heaping and thus

obscuring the successful competitor, a method was developed which required a rearing response. By using small food pellets the problems arising in food competition described by Syme et al (1974) were avoided.

In methodology the present study bears some resemblance to that of Varley and Symmes (1966) who studied a group of six macaques in groups of 2, 3, 4, 5 and the entire group. A succession of peanuts were presented at a single source, and by systematically removing different monkeys from the colony and measuring the aggressive interactions and grooming, Varley and Symmes attempted to reconstruct the balance of forces giving rise to the six animal hierarchy. The results of competitive tests were used as indices of boldness, although no attempt was made to validate this measure.

#### 6.1.2 SUBJECTS

Subjects were 7 male hooded rats, Otago Strain (NZBWS) housed together since weaning. After reaching sexual maturity the subjects were housed in the cage serving as the competitive arena. A reversed night-day schedule was maintained and ad lib food and water were available. S's were approximately 120 days old at the beginning of the experiment.

#### 6.1.3 APPARATUS

The only apparatus was the home cage, half of which also served as the competitive arena. This was a 4.5 x 5.5 x 4cm high wooden box with a wire mesh lid. The arena could be divided in two by a hardboard partition. A 19.5cm wide perspex window extending from floor to ceiling in one half of

the box permitted observation of the subjects in the test arena. A 3cm hole in the window 15cm above the floor permitted access to a small perspex bin. The diameter of the hole was such that one rat could poke its head into the bin at a time.

The rewards were small commercially produced pellets of the type normally used in operant studies on rats. While the experimental procedure was being developed all S's had experience with these pellets.

#### 6.1.4 METHOD

In order to control for possible motivational differences and changes within the experimental sessions S's were individually tested prior to the commencement of the experiment. All testing was conducted with the centre partition in place. For two days prior to competitive testing S's were individually placed in the competitive arena with the remaining animals on the other side of the centre partition. A single pellet was dropped every 10 seconds into the small perspex bin and a record was kept of the consummatory behaviour of each rat. Each animal was given an average score representing the number of pellets eaten until the first 'miss'. A 'miss' was recorded where a pellet was not eaten before the succeeding pellet was delivered. The minimum of these scores was halved and this number (23) was set as the upper limit for success/day for any animal in subsequent competitive tests.

The competitive conditions were paired-comparisons (P - C) or group competition (G). The rotated pairs method was used for paired-comparisons, one encounter per animal per day. Thus a full round of paired comparisons took 7 days.

In competition competing animals were placed in the competitive arena while any non-competing subjects remained on the other side of the centre partition. Every 10 seconds a pellet was dropped into the bin until one subject had consumed a total of 23. The test was then concluded. For group competition this animal was assigned a rank of 1 and the remaining subjects were ranked according to the number of pellets consumed (successes). Under both conditions a record was kept both of the number of pellets consumed by each animal and the sequence of successes.

The order of conditions are summarized below.

DAYS	CONDITION	NUMBER OF ROUNDS
1-7	GI	7
8-14	P-CI	1
15-16	GII	2
17-23	P-CII	1
24-27	GIII	4
28-34	P-CIII	1
35-41	P-CIV	1
42-62	GIV	21

Throughout the experiment the group was fed approximately 200g of sheep nuts daily. Ad lib water was available except when animals were competing.

#### 6.1.5 RESULTS

The experiment was designed to answer two specific questions:

- (i) Do the competitive orders for overall success obtained from paired-comparisons reflect competitive success

in group encounters?

- (ii) Within group competition do the orders obtained for overall success agree with those obtained for other possible indices of priority?

These questions are dealt with in turn.

### Group Versus Paired Tests

Kendall coefficients of concordance and Spearman rank correlation coefficients were used to assess the reliabilities of the orders within each block of group testing. These are presented in Table 20. All values of  $W$  and  $\rho$  are significant ( $p < 0.01$ ). The final 21 days of group testing (GIV) have been treated as 3 groups of 7 sessions in order to demonstrate the development of a more stable order with increased trials. The 3 orders thus obtained were compared using Spearman correlation coefficients which are presented in Table 21.

For both modes of testing the reliabilities of orders across experimental conditions were similarly assessed and are presented in Table 22. Results of paired-tests were treated according to both win-loss and raw-score analyses. Correlations for the latter are presented in parentheses.

### Measures of Priority

The different measures of priority were compared using only data from the final 21 days of group testing (GIV). These sessions were divided into 3 blocks of 7 sessions in order to assess reliabilities.

(a) FIRST SUCCESSES: S's were given a daily rank on the basis of the order of first successes and Kendall coefficients of concordance were calculated to assess reliabilities within each block of 7 sessions. The resultant values ( $W = 0.31$ ,

0.19, 0.41) indicated that only orders for the final 7 sessions were reliable ( $p < 0.05$ ).

(b) TOTAL NUMBER OF SUCCESSES PER SESSION: The Kendall coefficients of concordance for each block of tests were significant ( $W = 0.66, 0.73, 0.92$  in each case  $p < 0.01$ ).

(c) BETWEEN-SUBJECT TRANSITIONS: Transition frequencies are presented in Table 23 from which probability and conditional probability matrices were obtained in the manner described in Experiment 8. These matrices which are presented as Tables 24 and 25 were derived from observations over the entire 21 sessions in order to compare observed results with those expected by chance. Expected frequencies were too low for such a comparison when blocks of 7 sessions were used. The expected probabilities for Table 25 were 0.17 for each cell other than the leading diagonal.

Expected and obtained frequencies were then compared using a series of  $\chi^2$  tests as in the previous chapter. The results are presented in Table 26. The expected frequencies for  $S_i \rightarrow S_1$  transitions were too low to apply the  $\chi^2$  test, but all other rows yielded significant values of  $\chi^2$ . Each rat was ranked on the basis of the probabilities in each row of Table 25 and an overall rank derived which is presented in Table 27.

(d) CONSECUTIVE SUCCESSES: For each subject the proportion of successes which were consecutive in each block of 7 sessions was calculated. Subjects were given three ranks on the basis of these proportions. A Kendall coefficient of concordance showed these orders to be reliable ( $W = 0.63, P < 0.05$ ).

In order to compare orders obtained under the different

measures the orders (apart from that based on between-subject transitions) are presented for the final 7 sessions when measures were reliable (Table 27). The order for between subject transitions was derived from observations over the entire 21 sessions. Correlations between orders are spurious since they are related.

#### 6.1.6 DISCUSSION

The orders for group competition were reliable within each block of tests ( $p < 0.01$ ). The correlations between each of the first three blocks of group testing were significant ( $p < 0.05$ ), but the order for GIV correlated significantly only with GIII ( $r = 0.71$ ,  $p < 0.05$ ) this value being close to the critical level. The orders within GIV are reliable and the coefficient of concordance increases with each block of trials. While GIV is separated from the preceding group competitions by two rounds of paired-comparisons (14 days), the reduced reliabilities are probably not due to the temporal factor alone. GI and GIII are separated by 16 days yet the correlation is 0.86. The behaviour of one subject in the paired-encounters may have affected the relative performances in the group context. This subject which was ranked bottom in the first 3 blocks of group testing rose to be first equal in P-CIII and clear first in P-CIV. In later paired encounters (P-CIII and P-CIV) this animal typically bit any opponent which put up sustained opposition at the reward source. The bitten opponent would usually squeal and remain on the opposite side of the arena for the remainder of the trial. Opponents generally contended vigorously but this was the only rat to display behaviour

which was so clearly aggressive. The behaviour was not observed in the group context but group orders may have been disrupted nonetheless.

The orders for paired encounters were less reliable than the group orders. However P-CIII and P-CIV correlated significantly ( $\rho_{\text{win-loss}} = 0.85$ ,  $\rho_{\text{raw score}} = 0.94$ ). This may have been due to their temporal proximity but it is likely that stability in competitive orders is dependent upon practice at the competitive task. In this respect the paired and group tests are not comparable - 34 rounds of group competition were observed while subjects only competed in 4 rounds of paired-comparisons. The drop in reliability of  $GIV_{1-7}$  to a level comparable to that of GI may be attributed to the disrupting effect of the paired encounters.

Of the two methods of analysing paired encounters, Syme (1974) suggests the raw-score analysis has been typically used in rodent studies because reliable orders are more easily obtained. This is not so in the present study. Syme goes on to suggest that the validity of the two approaches is a theoretical issue which needs to be resolved.

Which analysis is appropriate depends upon the interpretation given to the competitive scores. If the scores reflect response dependent competitive success rather than measures of unidimensional dominance, then it is the outcome of each dyadic encounter which is important and the win-loss analysis is the correct one. In this case care is needed in the interpretation of rank orders. Hierarchies may not best represent the relative successes of subjects, and a graphical approach may be less misleading where the number of subjects is not too great. Given the traditional approach, however,



there are other considerations. The validity of the paired-comparisons procedure needs to be established. Reports of alliances and dependent rank particularly in primates (Rowell, 1974) are indicative of shortcomings in this procedure. The present study suggests that stable but different orders may be obtained under the paired and group approaches. Under these circumstances the latter is the more valid. This need not be at variance with Bartos' (1971) criteria but merely adds a qualification - dyadic encounters should be observed in the group context, as in the assessment of peck orders.

The orders obtained under the four measures of priority are all very similar though this is not altogether surprising. Given a high frequency of success a high frequency of early successes would be expected by chance. This is also true of both the proportion of consecutive successes and the between-subject transitions. However, the present experiment gives no grounds for attributing results on one measure to results on another in any causal sense. All that can be concluded is that the orders are in close agreement.

Regarding the two conditions specified at the beginning of the chapter, this experiment has shown:

- (i) that paired-comparisons and group testing yield different competitive orders, and that paired-comparisons may in fact disrupt group orders,
- (ii) that the overall competitive success measure yields orders close to those obtained from the other measures.

#### Paired Comparisons and Group Testing:

Few studies have examined group competition in laboratory rats. Krames, Carr and Bergman (1969) found

reliable orders for food competition, but in the absence of an independent measure of dominance the results do not provide strong support for traditional dominance theory. Baenninger (1968) and Grant and Chance (1958) similarly explored only one test of dominance, finding reliable orders for spontaneous encounters in groups of four rats. Baenninger (1970) found reliable orders for food, water and spontaneous dominance. Food and water dominance orders were correlated, but 'spontaneous' orders were unrelated to either of these. As previously mentioned the internal validity of these measures was not established. Thus while these results suggest a lack of unidimensionality they are not conclusive. Baenninger (1970) states, "Spontaneous fighting in laboratory rats may be akin to play; it may include all the movements and postures of wild rats fighting but may lack much of the aggressive motivation." Barnett (1963) notes the complete absence, in laboratory rats, of the threat posture, which is a usual feature of aggression in wild rats. He adds "'Fighting' in general was mild and resembled the playful wrestling of immature or female wild rats, not that of adult males." If the behaviour measured by Grant and Chance (1958) and Baenninger (1968, 1970) is not unequivocally aggressive, it need not be related to competitive success, however, orders for food and water dominance should be correlated. Whether Baenninger's (1970) results support or challenge unidimensional understanding of dominance thus depends upon the classification of spontaneous encounters as aggressive or non-aggressive. The reduction with time in frequency of spontaneous encounters (Grant and Chance, 1958; Baenninger, 1968) may be attributable either to the establishment of

stable dominance relationships if the encounters are aggressive, or to a reduction in play. Baenninger suggests the reduction is largely due to age. An age x familiarity factorial experiment would help to resolve this.

#### Measures of Priority:

The concordant orders derived from the four measures suggests that changing from overall competitive success to one of the other indices is not going to resolve the differences in competitive orders obtained in different contexts.

#### 6.1.7 CONCLUSION

To the extent that the first condition (paired-comparisons yield different orders than group tests) has been demonstrated the traditional dominance concept could possibly be maintained. However, the failure to reject the concept is insufficient grounds for retaining it. The focus of this chapter has been this negative aspect, but another side of the problem is perhaps of greater importance. This is the question of the positive value of the concept. This becomes more significant as the concept is modified from unidimensional to global, and from general across all species to specific to a particular group of species. The returns for propping it up seem meagre and even negative so long as "dominance" remains so poorly defined. In Chapter 1 it was stated that the retention of the dominance concept was challenged by three negatives:

- (i) There is no clear definition of dominance (this refers to the traditional rather than the mathematical view).
- (ii) There is no clear function of dominance.

(iii) There are no generally accepted means of measurement.

So far this thesis has focussed on (iii), and to this point no solution appears any closer. In retrospect, a theoretical approach to the problem of definition may have been more fruitful. This approach has been hitherto avoided because of the dilemma referred to in Chapter 5, whereby the definition is partially pre-behavioural, and the behaviour pre-definitional. In the following chapter a theoretical approach is taken to the three problems above.

TABLE 20: RELIABILITIES OF GROUP COMPETITIVE ORDERS

<u>Condition</u>	<u>Reliability</u>	<u>Significance</u>
GI	$W = .65$	$p < 0.01$
GII	$\rho = .95$	$p < 0.01$
GIII	$W = .92$	$p < 0.01$
GIV <sub>1-7</sub>	$W = .66$	$p < 0.01$
GIV <sub>8-14</sub>	$W = .73$	$p < 0.01$
GIV <sub>15-21</sub>	$W = .92$	$p < 0.01$

TABLE 21: SPEARMAN CORRELATIONS BETWEEN THE FINAL THREE  
BLOCKS OF SEVEN SESSIONS

	GIV <sub>1-7</sub>	GIV <sub>8-14</sub>	GIV <sub>15-21</sub>
GIV <sub>1-7</sub>	-	0.96	1.00
GIV <sub>8-14</sub>		-	.96
GIV <sub>15-21</sub>			-

**TABLE 22: CORRELATIONS BETWEEN COMPETITIVE ORDERS FOR EACH  
EXPERIMENTAL CONDITION**

	GI	P-CI	GII	P-CII	GIII	P-CIII	P-CIV	GIV <sub>1-7</sub>
GI	-	.54 (.54)	.88*	.18 (.32)	.86*	-.09 (-.12)	-.04 (-.14)	.57
P-CI		-	.63 (.63)	.50 (.46)	.25 (.25)	-.27 (-.57)	-.52 (-.68)	-.32 (-.32)
GII			-	-.01 (-.12)	.74*	-.26 (-.30)	-.26 (-.33)	.26
P-CII				-	.04 (.07)	.38 (.29)	-.04 (.14)	-.07 (.00)
GIII					-	-.07 (-.01)	.00 (-.11)	.71*
P-CIII						-	.85* (.94)*	.09 .28
P-CIV							-	.67 (.46)
GIV <sub>1-7</sub>								-

\* Significant at the 0.05 level.

TABLE 23: TOTAL FREQUENCY OF  $S_i \rightarrow S_j$  TRANSITIONS

	S1	S2	S3	S4	S5	S6	S7	TOTAL
S1	3	1	4	5	6	1	6	26
S2	0	8	4	9	28	1	10	60
S3	2	6	37	35	59	21	31	191
S4	5	10	27	74	75	14	74	279
S5	6	16	67	65	139	19	118	430
S6	2	3	13	17	28	6	18	87
S7	4	14	39	76	103	23	80	339
TOTAL	22	58	191	281	438	85	337	

TABLE 24: TRANSITION PROBABILITIES ( $S_i \rightarrow S_j$ ) FOR EXPERIMENT 9

		Subjects						
		1	2	3	4	5	6	7
SUBJECTS	1	.12	.04	.15	.19	.23	.04	.23
	2	.00	.14	.07	.14	.47	.02	.17
	3	.01	.03	.19	.18	.31	.11	.16
	4	.02	.04	.10	.27	.26	.05	.27
	5	.01	.04	.15	.16	.32	.04	.27
	6	.02	.03	.15	.20	.32	.07	.21
	7	.01	.04	.11	.23	.30	.07	.24

TABLE 25: MATRIX OF CONDITIONAL PROBABILITIES  $P(S_i \rightarrow S_j | S_i \text{ does not follow itself})$

	S1	S2	S3	S4	S5	S6	S7
S1	0	.06	.17	.22	.26	.05	.26
S2	.00	0	.08	.16	.55	.02	.20
S3	.01	.04	0	.22	.38	.14	.20
S4	.03	.05	.14	0	.36	.07	.37
S5	.01	.06	.22	.24	0	.06	.40
S6	.02	.03	.16	.22	.34	0	.23
S7	.01	.05	.14	.30	.39	.09	0

TABLE 26: RESULTS OF  $\chi^2$  TESTS BETWEEN THE EXPECTED AND OBSERVED FREQUENCIES FOR BETWEEN SUBJECT TRANSITIONS IN EXPERIMENT 9

<u>Transitions</u>	<u><math>\chi^2</math> (df = 5)</u>	<u>Significance</u>
S1 $\rightarrow$ S <sub>j</sub>	-	-
S2 $\rightarrow$ S <sub>j</sub>	61.06	$p < 0.001$
S3 $\rightarrow$ S <sub>j</sub>	85.43	$p < 0.001$
S4 $\rightarrow$ S <sub>j</sub>	150.49	$p < 0.001$
S5 $\rightarrow$ S <sub>j</sub>	189.22	$p < 0.001$
S6 $\rightarrow$ S <sub>j</sub>	35.97	$p < 0.05$
S7 $\rightarrow$ S <sub>j</sub>	172.85	$p < 0.001$



TABLE 27: RANK ORDERS ON THE FOUR MEASURES OF PRIORITY

<u>Subject</u>	<u>Proportion of Successes Consecutive</u>	<u>First Successes</u>	<u>Between Subject Transitions*</u>	<u>Total Number of Successes</u>
S1	6.5	6	7	7
S2	6.5	7	6	6
S3	4	4	4	4
S4	2	3	3	3
S5	1	1	1	1
S6	5	5	5	5
S7	3	2	2	2

\*The order for between-subject transitions was derived from data obtained in sessions 42-62; other orders were derived from data obtained in sessions 56-62.

## CHAPTER SEVEN

### CONCLUSION

In Chapter 1, and again in the previous chapter, three areas were specified in which dominance theory is inadequate: the areas of measurement or assessment, function and definition. In this chapter these areas are further examined.

#### 7.1 THE MEASUREMENT OF DOMINANCE

The problem of measurement has been the focus of the preceding chapters. The earliest studies by Schjelderup-Ebbe (e.g. 1922) were concerned with peck orders. While pecking may be considered aggressive behaviour, studies of aggression are more often concerned with a wider range of behaviours (e.g. threats, King, 1965). There are a number of problems arising from the use of any aggression orders as indices of dominance.

- (i) Aggression orders may not reflect other priorities e.g. Syme & Syme (1974), Baenninger (1970). Van Krevelds (1970) suggestion that aggression orders should be used where there is no clear priority order indicates this.
- (ii) Definitions of dominance now in use, though inadequate, give no grounds for preferring the aggression index over other possible indices.
- (iii) Among stable groups, where dominance relations are considered to be settled, there is frequently little or no aggression, thus rendering the index unusable.
- (iv) An inverse relationship is reported between dominance

"distance" and the frequency of aggressive encounters (Bernstein, 1970).

- (v) The stereotyped aggressive behaviours of some species preclude testing for response rather than social mediation (Syme, 1974).

For laboratory rats a recent non-competitive alternative to aggression is the grooming index (Spigel, Trivett and Fraser, 1972; Spigel and Fraser, 1974). This has already been discussed in Chapter 3 but by the reasoning of its advocates is essentially another form of the aggression index - rats aggress for the right to groom, therefore the animal of any pair spending the greater time grooming must be the "dominant" animal. If the grooming index is a special form of the aggression index the problems above, with the possible exception of (v), apply equally to grooming. If not, there are problems nonetheless.

- (i) Grooming may not reflect other priorities.
- (ii) Definitions of dominance now in use give no grounds for preferring the grooming index over other possible indices.
- (iii) In laboratory rats such as Spigel, Trivett and Fraser (1972) use there is little grooming in group situations. In order to use the index the animals must be isolated and deprived of opportunities to groom. The present author had to abandon one study because the amount of grooming was too low when an attempt was made to use the grooming index to assess intragroup relationships.
- (iv) The grooming index is species-specific, e.g. in rats the dominant animal of a pair is the one which grooms (Spigel, Trivett and Fraser, 1972); in primates the dominant animal is groomed (Hinde, 1974).

Having rejected both aggression and grooming as indices of dominance, the alternative, competition, is equally unattractive. It is now quite clear that the assumption of generality in competitive orders is not justified, and the problems with using these orders as indices of dominance status may be summarized as follows:

- (i) One competitive order may not reflect other competitive orders (Syme, 1974; Chapter 2).
- (ii) Definitions of dominance now in use give no grounds for selecting one competitive order over other orders.
- (iii) Not all competitive orders reflect socially mediated priorities (Syme, 1974; Chapter 2).

Thus, none of the present means of measuring dominance are adequate.

Competitive testing which is the most frequently used means, while not viable as a dominance index, requires standardization for studies of competition per se. Syme (1974) compiled a list of methodological problems which must be solved before procedural standardization of competitive tests can be achieved. The points raised by Syme are briefly discussed below in the light of the present thesis.

#### 7.1.1 STANDARDIZATION OF COMPETITIVE TESTS

(a) Syme questions the relative validities of the time and weight measures of success in limited access competitions. If the concept of dominance is discarded there is no question of a priori validity. Future experimental work may reveal that only one index reflects a socially mediated priority, but if both indices are valid, urination and defecation can affect the weight index. The discrete reward procedures

(e.g. Chapter 6) are one means of sidestepping this whole problem.

(b) The suitability of crediting a win on the basis of which animal gains more of the competitive measure has not been established. This is important in view of both the individual differences in skill at the competitive task, and the fluctuations in performance. Syme et al (1974) have pointed out the necessity of a suitable competitive period as a solution to one aspect of this problem. However, where the weight measure is used an additional control must be sought. This was done in Experiment 1 where compensation was made for expected levels of performance.

(c) In assessing reliabilities of competitive orders both win-loss and raw score analyses have been used. These two modes of analysis were discussed in Chapter 5. It does appear that the win-loss method of analysis is the only valid one.

This leads to a further consideration relevant to work on peck orders which are derived merely from the number of pecks exchanged between pairs of birds. In the past no attempt has been made to compare these differences with those to be expected on a chance basis. The overall frequency of pecking for each bird could be taken into account in the same way as the competitive scores were analysed in Chapter 5, Experiment 8. Dyadic interactions could thus be examined with control for differences in levels of aggression.

(d) Syme points out that while many studies used paired-comparison techniques and some use whole-group competition, there have been few systematic investigations as to which is the more useful procedure. He writes, "If authors wish to use the concept of dominance they must decide which of the

orders obtained reflects this phenomenon should discrepancies be found." (Syme, 1974). The argument in Chapter 5 was that in studies of dominance, group orders are the relevant ones although paired-comparison methods are used most often. Since the problem is standardization of competitive tests, this needs to be faced again. Group testing does permit testing in the home cage but pairs provide a simple means of assessing the success of each subject relative to each other. Ultimately the question is not one of validity but of convention and there should be standard procedures for tests of both types.

(e) The theoretical utilities and effects on competitive behaviour of limited access and all-or-nothing competitions have still not been compared: procedures seem to be chosen only on the grounds of expediency. A theoretical analysis seems a primary requirement since any classification is dependent upon underlying assumptions which need to be examined. There are therefore two problems:

- (i) What are the classes? and
- (ii) Which tests fit into which classes?

Syme's classification into limited access and all-or-nothing competitions is not the only one possible, an alternative could be continuous versus discrete-reward situations. Any classification is likely to leave questions about some tests. For example, Syme's classification of Bruce's (1941) technique as a limited access one might be challenged. Bruce's method involves giving two animals a single food pellet. The time each animal controls the pellet (or weight consumed, (James, 1949) ) is the index of success. This procedure does not differ greatly from the discrete reward techniques and

classification is therefore difficult. Ultimately this type of problem requires an empirical solution, but the general problem of classification is one in which neither a purely empirical, nor a purely theoretical approach is likely to be fruitful.

(f) Among the minor methodological considerations raised by Syme are discrepancies in levels of deprivation. Levels will have to be set somewhat arbitrarily within limits which are determined empirically.

A parallel problem concerns the amount of habituation. Again an empirical approach is required, but there will be no solution to the problem until the other aspects of competition are fixed, e.g. the nature of the competitive arena, the amount of deprivation. Two approaches were taken to the problem in this thesis. In the first, baseline measures were taken and this phase prolonged until differences between groups disappeared (Chapter 2, Experiment 1). Later, testing was conducted in the home cage.

If this list comprises most of the specific obstacles to standardization of tests, the overall problem can be viewed as a type of form-freedom dilemma. The freedom required is a diversity of competitive tests. Syme (1974) writes of the apparent "urgent need" for further studies to use such a diversity with systematic changes in the response requirements thus permitting a check of internal validity. Where a low correlation between tests was demonstrated a response interpretation would have to be given and priorities could not be interpreted as being socially mediated. Similarly, there must be a number of different tests in order to discover the generality of competitive orders. A different aspect of

freedom requirement was discussed in Chapter 4. This involved the possible discovery of relevant parameters by breaking with traditional procedures.

Set against this need for freedom there is an obvious need for form. Work involving environmental and chemical manipulation has been concerned with the effects of such manipulations upon competitive performance (or more frequently, dominance). Clearly diversity in competitive tests limits the comparisons that can be made between studies, and the sooner testing procedures are standardized the better. In the meantime the tension between freedom and form will remain.

In conclusion, there needs to be a cautious approach to the study of competitive behaviour. The concept of dominance has proved misleading, and a vague concept of competition could be similarly misunderstood. It needs precise definition, avoiding, for example, the connotation of purposiveness.

## 7.2 THE FUNCTION OF DOMINANCE

Van Kreveld (1970) suggested three possible functions of dominance which represent all of those commonly ascribed to dominance. Since there are no generally accepted means of measuring dominance, the various views regarding function are untestable. However, even if this were ignored the literature gives little grounds for inferring any of the functions.

Van Kreveld's (1970) three functions of dominance were presented on the basis of Wynne-Edwards' (1963, 1965) theory of homeostatic stability by which intrinsic mechanisms regulate population size within a given habitat. These mechanisms are given in place of Darwin's four external factors:



the amount of food available, the effects of predation, disease, and physical factors such as climate. It is suggested that one internal adaptive mechanism is dominance which has three functions.

(i) It serves an integrative function facilitating group defense of territory in intergroup clashes. Reduced aggression between groups results from dominance relations being settled by overloads.

However, Rowell (1974) makes it clear that dominance status cannot be inferred from defensive reactions. For example, adult male monkeys of most species approach a source of danger while females and infants flee. In many of these species the male is much larger than the female and predictably ranks higher in competitive tests where weight and height are significant factors. In many other species females may be higher ranking than males, yet it is still the males that show defense behaviour.

(ii) Dominance likewise reduces intra-group aggression, protecting the group from falling apart.

However, hierarchies are most clearly seen where these are high levels of aggression, and there is no evidence that the establishment of a hierarchy per se provides feedback to reduce aggression (Rowell, 1974).

(iii) It promotes an effective birth control mechanism.

"The hierarchical system ensures that subordinates die of starvation in times of food shortage, that they do not breed, and that their sexual development is inhibited... Dominance... works as a feed-back mechanism, controlling how many, and which animals eat and reproduce themselves, and to which extent they reproduce themselves" (Van Kreveld, 1970).

The most obvious weakness here is the assumption of unidimensionality. It is not clear that dominance is positively correlated with sexual activity, e.g. De Vore (1965) describes the relative sexual inactivity of the highest ranking male baboons, a phenomenon also noted in sheep (Winfield, Syme and Makin, 1975). In addition, it has already been noted in Chapter 1 that evidence of reproductive success from priority of access to females is equivocal since receptive females do not always contain ripe ova.

In the absence of adequate means of measuring dominance, proposed functions are obviously untestable. However, the most fundamental problem is not that of measurement but of defining dominance, for until the concept is better defined, questions about both measurement and function are unanswerable.

### 7.3 THE DEFINITION OF DOMINANCE

Rather than examining the various definitions of dominance which have appeared in the literature, or attempting to improve upon them, the aim in this section is to specify the types of definition which could be given, and to show that none would provide a definition of dominance warranting the retention of the concept. The possible types of definition are listed below:

#### 7.3.1 DOMINANCE AS A GENERAL PRIORITY OF ACCESS

Priorities which were initially used as operational criteria for dominance, have now, by widely accepted definition, become equated with the term (e.g. Van Kreveld, 1970). Definition of dominance as a general priority of access,

logically at least, can be understood in three ways.

(a) The definition could be stipulative, i.e. of the form: 'Let us mean by 'dominance' the priority that one animal has over another toward an approach situation or away from an avoidance situation'.

The most serious objection to a stipulative definition such as this is the absence of a demonstration of any general priority. The possible exception to this is in primate behaviour (Richards, 1974), but as Syme (1974) points out, 'dominance' has been applied to all vertebrates including fish and amphibia, and to some invertebrates as well. Further, since an arbitrary convention is being laid down there is good reason to choose an alternative term to 'dominance'. The danger in the definition is that 'dominance' is already a connotative word. A more cautious approach would favour an alternative. Possibly 'priority' or different 'priorities' could be used with no other term. The old assumption of unidimensionality might have died more quickly and attention could have been given to the definition of 'priority' and to the generality of priority rights.

(b) The definition could be an analytic or philosophical definition. The focus on empirical data rather than linguistic analysis to provide support or refutation of the definition shows that this is not the case. Dominance theory appears to have had an effect on linguistics rather than vice versa. For example, Websters Third International Dictionary gives us one meaning of 'dominance', "the relative position of an animal in the social hierarchy of its kind". A single social hierarchy may be inferred.

(c) The definition may be extensional. An extensional definition is a descriptive definition differing from an analytic definition in that the definiens is not intended to have the same meaning as the definiendum, but rather the same extension, i.e. the definiens provides necessary and sufficient conditions for the definiendum. Hence, "Dominance" has the same extension as "the priority that one animal has over another..." This appears to be the type of definition sought over the last decade. Such definitions can neither be established nor refuted on a priori grounds but demand an empirical approach. However, from the literature there are at least two objections to classing the definition of dominance by priority rights as extensional.

(i) Dominance appears to be widely understood as an intervening variable, mediating priorities and present whether or not priorities are being demonstrated. Chance (1956) writes, "Dominance is usually defined as priority of access to a need satisfying object, but since in this instance no priority of feeding was shown, it was in the relations of the animals to each other that the order of rank was made manifest".

Thus, despite the definition, a distinction is drawn between dominance status and priority. Absence of dominance is not inferred from absence of priority, and dominance is viewed as a necessary but not always sufficient condition for priority rights.

(ii) An implication of this is the acceptability of a diversity of priorities while maintaining a single dominance structure. For example, Van Kreveld (1970) writes, "The priority rights for access to different situations (e.g. sex and aggression) do not always go together completely... In such situations it seems most meaningful to define

dominance on the basis of aggressive encounters...".

In addition to these two <sup>objections</sup> objections, the absence of a demonstration of general priority rights is as significant to an extensional definition as to a stipulative one. Thus it is clear that no interpretation of the definition of dominance in terms of general priority of access warrants the retention of the concept.

### 7.3.2 DOMINANCE AS A PARTICULAR PRIORITY

As the underlying problem with defining dominance in terms of general priority is the lack of unidimensionality, so the underlying problem with defining dominance as a particular priority is redundancy. Whether the definition is stipulative or extensional there is no advantage in retaining the concept. (There is no question of an analytic definition). A particular priority can be readily defined in terms of its response components, and the undesirable connotations of 'dominance' avoided.

### 7.3.3 DOMINANCE AS A PHYSIOLOGICAL CONDITION

There are two major problems with defining dominance as a physiological condition. Firstly, the lack of empirical justification, and secondly redundancy. In her review of the primate literature, Rowell (1974) states that dominance has no known physiological correlate. Animals identified as low-ranking do show a greater incidence of stress related diseases and greater adrenal responsiveness, but the absence of a physiological correlate with dominance precludes any extensional definition. If at some stage a physiological

condition was found to correlate with certain tests of dominance, a definition in terms of this condition would make 'dominance' redundant.

#### 7.3.4 DOMINANCE AS A THEORETICAL CONSTRUCT

The only reason remaining for the retention of the concept of dominance hinges on a demonstration that it provides a useful theoretical construct or model yielding an economical explanation for a diversity of behaviours. As such 'dominance' would be extensionally defined. While the absence of unidimensionality argues against this, Syme (1974) and Richards (1974) point out the justification in retaining the concept if concordant priorities can be demonstrated in a number of different contexts, though not necessarily all. Two issues are involved: the demonstration of such concordance, and the labelling of any intervening variable postulated.

The first is an empirical problem. Richards (1974) has shown significant correlations between various measures in studies of rhesus monkeys, but similar work, comparing a number of different measures, is required on other species. If significant correlations are demonstrated a cautious approach is required in labelling any intervening variable, and 'dominance', as a connotative word would be better avoided. Nor should an entirely new concept be automatically sought. The concordant findings in competitive settings could be particular cases of a more general phenomenon even when the condition of internal validity has been met. For example, differences in reactivity to the environment may be reflected in socially mediated competitive behaviour. To postulate another intervening variable would be both

uneconomical and misleading. Further research may reveal a need for some construct akin to dominance (preferably with an alternative name) but at this stage there is insufficient grounds for retaining the concept.

Summarizing, on the basis of this analysis there appears little hope of arriving at any definition of dominance which would warrant the retention of the concept within an objective science. There are no grounds for accepting any of the possible types of definition, and the term "dominance" already carries connotations which render it virtually unusable.

#### 7.4 REJECTION OF THE CONCEPT OF DOMINANCE

The problems of measurement, function and definition, each lacking reasonable solutions, leave the concept of dominance in an indefensible position. The three problems are themselves inter-related - a solution to the question of function hinges on the discovery of adequate means of assessing dominance. This in turn depends upon the meaning of "dominance". Thus, the fundamental problem is that of definition. If, in the present thesis, this had been centred on, the ultimate futility of trying to find appropriate indices of dominance would have become evident.

In view of the analysis in this Chapter, it seems a pity that so little notice was taken of Gartlan's (1964) assertion that the concept of dominance had probably done more harm than good and should therefore be abandoned. Perhaps it has only retained respectability because of the lack of clarity surrounding it. The elusiveness of definition made

it difficult to reject as a concept, and the failure to find a widely accepted index of dominance went largely unnoticed since workers assumed they were measuring some transcendent factor. The fact that this factor was not defined was overlooked. Now, however, the concept should be rejected, and the term 'dominance' avoided.



APPENDIX

## PROBLEMS IN THE ANALYSIS OF COMPETITIVE DATA

G.J. SYME AND J.B. DOAK

SUMMARY

While a number of studies have investigated the effects of experimental manipulations on the competitive behaviour of laboratory rodents, little systematization has been achieved in either experimental design or statistical analyses. This paper reviews the analyses used in a number of competitive studies and concludes that between-group competitive experiments should be analyzed with one-sample statistics. It suggests that if the one-sample chi square is used, the expected frequency should be calculated from the number of subjects in the experimental group and recommends reanalysis of some competitive experiments.

INTRODUCTION

A number of studies have investigated the effects of various behavioural manipulations on the competitive behaviour of the laboratory rat. Early experience (Becker and Ezinga 1969; Becker and Gaudet, 1968), drug effects (Uyeno, 1966; Masur, Martz, Bieniek and Korte, 1971), social isolation (Hoyenga and Lekan, 1970; Ward and Gerall, 1968), and motivational conditions (Hsaio and Schreiber, 1968; Syme and Pollard, 1972), have all been shown to influence competitive performance.

Three basic designs have been employed in these studies. First, a relatively large number of animals are designated to the experimental condition, and these are placed in competition once with an equal number of control animals. The effects of the experimental manipulation are then calculated from the number of winners which belong to the experimental and control conditions (Heimstra and Sallee, 1965; Uyeno and White, 1967). Second, fewer experimental subjects can be employed, these being placed in competition against all of an equal number of control animals (Rosen, 1958, 1961, 1964). The final progression in this series of experimental design (Becker, 1965) requires all of a small experimental group to compete with one another as well as the group of control subjects.

#### ANALYSIS

Although the mode of analysis in the first type of study is relatively clear-cut, in that the numbers of winners from the experimental group are compared against chance values on either a binomial or a one-sample chi square test, the analysis for the remaining designs has been variable and, as this paper will attempt to show, often inappropriate.

Before a between-group comparison of competitive behaviour can be made, there is one important limitation of competitive data which must be considered. If the methodology of the study has been adequate, the score for each opponent in a competitive situation bears an ipsative relationship to that of the other. If one rat scores highly, the value for the other must be low. Thus any comparison

between the values of the two opponents must be regarded as spurious, and, consequently, any analysis of competitive data in a between-groups experiment must be executed in terms of its being a one-sample experiment with the performance of the experimental group being compared against chance values.

The relevance of this allowance for the ipsative nature of competitive data is illustrated by the analyses of Rosen (1958, 1961, 1964) and Rosen and Hart (1963). In the first three studies Rosen, while trying to demonstrate the effects of social isolation and early handling on competitive behaviour in the rat, allowed his experimental animals to compete with all his control animals.

For this analysis, however, this author compared the means of his experimental and control animals by means of a *t* test for independent samples. Clearly this was inappropriate, since the scores obtained for this experimental animals were dependent on those obtained by his controls. A similar criticism can be levelled at the Rosen and Hart study (1963), in which the competitive performances of isolated mice were compared with those of grouped controls with the use of the same design as that employed in the studies previously mentioned. Here a Mann-Whitney *U* test was used to compare the competitive scores of the animals in each group. Again, this test assumes independence of the scores obtained by each group and must be considered inappropriate. A similar problem was encountered by Uyeno (1960) who, in a more complicated design than that employed by Rosen, compared the competitive behaviour of four groups each of which competed with all of the other animals. Rats born of dominant and submissive parents were placed in the care of either dominant or

submissive foster mothers in a 2 x 2 design. For the analysis of this experiment Uyeno calculated an analysis of variance and later compared the adjusted means of his groups. Even though his experimental design was considerably more complex than those of the previous studies discussed here, the data gained for each group bore an ipsative relationship to that obtained for the others. Consequently, it is doubtful whether a comparison between means in such a circumstance is valid.

A more correct analysis for all of these studies would have been either to compare the total competitive score of each experimental animal with a chance value, and test for significance with an appropriate statistical test, such as a Sign test or Wilcoxon matched-pairs signed-ranks test, or to calculate the number of rats which won more competitions than they lost and compare this number with a chance value with the use of a one-sample chi square test.

A similar disregard for the ipsative nature of competitive data may be seen in the experiment reported by Syme and Pollard (1972). This study demonstrated the effects of increasing hours of food deprivation on competitive behaviour in rats. In their design eight subjects were tested in four pairs under two levels of deprivation. For each pair two competitive tests were conducted with the subjects alternating between high and low deprivation conditions. The data were analyzed by comparing the performance of each subject under both motivational conditions and by means of a Wilcoxon matched-pairs signed-ranks test. Since all animals improved their performance under the high motivational conditions, it was concluded that increases in deprivation levels improved competitive performance. While, in a sense, this

can be deduced from their data, these authors fail to consider the fact that if one of their pair of subjects improved under the high motivation conditions, the score of the other must also have improved, as its performance was a reflection of its opponent's. Thus for their mode of analysis Syme and Pollard had, in effect, only four subjects. A more correct usage of the Wilcoxon matched-pairs signed-ranks test would have been to compare the competitive values obtained by each subject with the chance level of 50%. Fortunately Syme and Pollard present their raw data, and, if this calculation is made, their conclusions are supported.

Further evidence as to the importance of analyzing competitive data between two groups as a one-sample experiment can be gained upon examination of the study by Becker (1965). Here the effects of early electrical stimulation on subsequent competitive behaviour were investigated. As noted earlier, this author not only required his experimental subjects to compete against all the control animals but against their groupmates as well. His method of analysis was to define those animals which won more encounters than they lost as winners, and the others as losers. He then placed both experimental and control frequencies in a 2 x 2 winners/losers table and analyzed them by means of a Fisher exact probability test - a test which demands not only two samples but also independent measures. Clearly the data obtained on this occasion, although not as directly related as in the design in which there is only intergroup competition, cannot be assumed to be independent. It may have been simpler and more meaningful for Becker to analyze his data only in terms of intergroup competition and then with a one-sample statistic.

Finally, it is worthy of note that, even if a one-sample statistic is adopted for this type of competitive study, care should be taken in the choice of expected frequency of success of the experimental group. Examples of this need for caution may be seen in the studies of Mezei and Rosen (1960) and Monroe (1970) which, by injudicious use of the one-sample chi square, exaggerated the strength of the data collected. In the first study 14 rats which had been handled were competed against each of 14 rats which had not been handled. The analysis employed was to consider each of the 196 competitive encounters as being independent events with the expected number of wins for the control group equalling 98. It is probable, however, that this assumption was not entirely justified. Essentially Mezei and Rosen's design was one of 14 subjects with 14 repeated measures. A more appropriate analysis would have allowed for this, and considered the number of experimental subjects as  $n$  for the chi square calculations. An adaption of method of analysis used by Becker (1965) may have been suitable. The number of wins by each experimental subject could have been counted with those winning more than half their competitions being designated as winners, and the number of winners being compared against the chance value of seven. At first this seems a minor distinction, but if the frequencies reported by Mezei and Rosen (1960) are examined, it can be seen that it is a rather important one.

In their study two competitive series were conducted, one 74 days after the first. For the first competitive series Mezei and Rosen report frequencies of 133 wins for the handled group and 63 for the controls, resulting in a chi

square value of 25 with a significance level of 1%. If the 63 wins recorded for the control group had been confined to seven animals, however, it can be seen that only seven of the experimental group may have been classified as dominant. An even more vivid example may be seen in the second series of dominance tests; here the number of wins for the experimental animals was 112 with a resultant chi square value of 4 and a probability of occurrence of less than 5%. But even though this value is significant, it is possible that six of the 14 experimental animals may have lost all their encounters. Mezei and Rosen's conclusion that handling improves competitive performance is not necessarily supported by their data. Such use of the one-sample chi square test requires that the expected win frequencies should be calculated from the number of subjects employed in the study.

A second, and even more marked example of this problem may be seen in the study by Monroe (1970). In this experiment Monroe compared the competitive behaviour of six rats which had undergone unsuccessful social experiences with each of six subjects who had had successful experiences on two occasions. For his analysis Monroe regarded his 72 competitions as having a chance probability of outcome and calculated his results in terms of expecting half the number of wins to occur in each group. Apart from the difficulties experienced in the interpretation of Mezei and Rosen's data, Monroe's design has the further limitation of possessing two observations of each of the possible pairings, and thus the results of the second round of competition cannot be regarded as being randomly distributed unless his original observations were unreliable.

As in the Mezei and Rosen study Monroe's observations should have been analyzed subject by subject; with his small number of subjects each of the six would have had to win more competitions than it lost in order to demonstrate a significant experimental effect.

### CONCLUSIONS

Experiments attempting to make intergroup comparisons should be analyzed in terms of one-sample statistics, and the expected frequencies for chi square tests should be based on the number of subjects rather than the number of competitive encounters. The exact effect of these statistical criticisms on the conclusions of the studies reviewed here cannot be determined, except in the case of that by Syme and Pollard (1972). Even though in this case the conclusions of the authors were upheld, reanalyses of the remaining studies along the lines suggested here may prove useful.



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